THE

South African Journal of Science

Volume XLIV

BEING THE

REPORT

OF THE

FORTY-FIFTH ANNUAL MEETING

OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

OUDTSHOORN
1947 —48
30th June to 4th July

JOHANNESBURG:
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Suid-Afrikaanse Joernal van Wetenskap

Deel XLIV

SYNDE DIE

VERSLAG

VAN DIE

VYF-EN-VEERTIGSTE JAARVERGADERING

VAN DIE

SUID-AFRIKAANSE GENOOTSKAP VIR DIE BEVORDERING VAN WETENSKAP

OUDTSHOORN
1947
30 Junie tot 4 Julie

JOHANNESBURG:
UITGEGEE DEUR DIE GENOOTSKAP
en
Gedruk deur GALVIN en SALES, BPK., Kasteelstraat 11, Kaapstad
1948

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TO

HIS MOST EXCELLENT MAJESTY

GEORGE THE SIXTH·

BY THE GRACE OF GOD·
OF GREAT BRITAIN · IRELAND
AND THE BRITISH DOMINIONS
BEYOND THE SEAS
KING · DEFENDER OF THE FAITH·
EMPEROR OF INDIA·

· MAY IT PLEASE YOUR MAJESTY ·

The Members of the South African Association for the Advancement of Science present their loyal duty to Your Majesty.

Recalling with pride Your Majesty's gracious consent to become the Patron of their Association, they desire faithfully to express their Loyalty and Devotion, and ever pray that Your Majesty may be blessed with long life, happiness and peace.

H. H. Paine

·President·

A. L. H. Blakeley

·1st April 1947· ·Honorary General Secretary·

THE

SOUTH AFRICAN JOURNAL OF SCIENCE

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(1947, OUDTSHOORN)

Vol. XLIV   MARCH, 1948   Vol. XLIV

EDITORIAL NOTE

Some explanation of the attenuated condition of this volume of the Journal may be desirable. This will be found on page XIV—"Report of Council, 11, Publications of the Association".

It is there stated that the Council had accepted a change in the policy with regard to publications, according to which the *Journal* would be reduced in bulk and at the same time improved in quality, etc. whilst the former quarterly Bulletin would be expanded into a monthly publication to be called *South African Science* and to contain reports and reviews on current science, notes on research and matter of scientific and general value.

The report of the Council was adopted by the annual general meeting of members held at Oudtshoorn on the 4th July 1947 (Proceedings, page iii, clause 3.).

This issue of the *Journal* is the first volume in which the new policy has to some extent been made operative, the scientific contributions covering 157 pages as compared with 393 pages in the last volume and with an *average* of 443 pages in the last ten volumes. This must however be considered in conjunction with a great increase in the content of the Bulletin which is not yet complete for the year 1947-48.

S. B. ASHER.

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PROCEEDINGS OF THE FORTY-FIFTH ANNUAL GENERAL MEETING OF MEMBERS, HELD AT THE BOYS' HIGH SCHOOL, OUDTSHOORN, ON FRIDAY, 4th JULY, 1947, AT 11.15 a.m.

VERRIGTINGS VAN DIE VYF-EN-VEERTIGSTE ALGEMENE JAARVERGADERING VAN LEDE, GEHOU IN DIE HOËR-JONGENSKOOL, OUDTSHOORN, OP VRYDAG, 4 JULIE, 1947, OM 11.15 v.m.

Present/Teenwoordig.—Professor H. H. Paine (President) (in the Chair), Mr. C. H. Adams, Miss R. J. Allsopp, Mr. I. J. M. Archer, Mr. S. B. Asher, Dr. L. A. Barradas, Miss S. I. Bodenstein, Dr. M. Boehmke, Dr. J. de O. Boléo, Dr. G. G. Cillie, Miss J. A. Coetzee, Professor R. H. Compton, Dr. G. de Kock, Professor C. G. S. de Villiers, Dr. H. H. Dodds, Dr. A. L. du Toit, Mrs. E. R. du Toit, Dr. R. A. Dyer, Mr. E. M. Evans, Mrs. E. L. Gray, Mr. James Gray, Miss V. C. Green, Dr. C. S. Grobbelaar, Dr. G. N. G. Hamilton, Dr. Marguerita Henrici, Miss M. E. Johns, Mrs. H. C. N. Jones, Mr. J. D. Rheinallt Jones, Dr. F. E. T. Krause, Miss J. S. Le Grice, Mrs. S. N. Lingnau, Mr. W. A. L. Lingnau, Miss M. E. Malan, Dr. A. McMartin, Dr. D. B. D. Meredith, Mrs. A. A. M. Mudd, Professor J. Omer-Cooper, Professor John Orr, Professor F. E. Plummer, Mr. D. J. J. Prinsloo, Mrs. E. J. Prinsloo, Professor A. Quintanilha, Miss. M. C. Schmitt, Dr. Bernard Smit, Mr. H. H. Steyn, Mr. P. J. Swart, Dr. Gertrud Theiler, Mrs. A. E. Thomas, Dr. E. C. N. van Hoepen, Mr. G. W. van Rooyen, Miss B. Williams, Dr. A. E. H. Bleksley (Honorary General Secretary) and Mr. I. M. Sinclair (for Assistant General Secretaries).

1. **Minutes.**—The Minutes of the Forty-Fourth Annual General Meeting, held at Pretoria on the 5th July, 1946, and printed on pages iii to xiv of the of the Report of the Pretoria Session (Volume XLIII of the Journal), were confirmed.

Notule.—Die Notule van die Vier-en-Veertigste Algemene Jaarvergadering, gehou te Pretoria op 5 Julie, 1946, en gedruk op bladsye iii tot xiv van die verslag van die Pretoriase Byeenkoms (Deel XLIII van die Joernaal) is goedgekeur.

2. **Greetings and Apologies.**—The Honorary General Secretary reported that messages for a successful meeting, together with their apologies for absence, had been received from Dr. J. S. Paraskevopoulos, Mr. F. R. Paver, Dr. E. Percy Phillips, Mr. J. H. Power and Dr. J. I. Quin.

It was noted that apologies for absence had also been received from Mr. R. Alexander, Mr. E. C. Chubb, Dr. H. B. S. Cooke, Mr. P. Freer, Dr. T. D. Hall, Mr. D. F. Kokot, Professor I. D. Mac Crone, Mr. B. D. Malan, Dr. R. J. Ortlepp, Reverend Noel Roberts, Dr. S. H. Skaife and Dr. L. H. Wells.

2. **Groete en Verontskuldigings.**—Die Ere-Algemene Sekretàris het gerapporteer dat boodskappe van heilwense vir 'n suksesvolle vergadering van Dr. J. S. Paraskevopoulos, Mnr. F. R. Paver, Dr. E. Percy Phillips, Mnr. J. H. Power, en Dr. J. I. Quin ontvang is.

Ontvange verontskuldigings vir afwesigheid is ook genoteer van Mnr. R. Alexander, Mnr. E. C. Chubb, Dr. H. B. S. Cooke, Mnr. P. Freer, Dr. T. D. Hall, Mnr. D. F. Kokot, Professor I. D. MacCrone, Mnr. B. D. Malan, Dr. R. J. Ortlepp, Eerw. Noel Roberts, Dr. S. H. Skaife, en Dr. L. H. Wells.

3. **Annual Report of Council for the year ended 30th June, 1947.**—The Annual Report of the Council for the year ended 30th June, 1947, having been duly suspended on the Notice Board, was taken as read and adopted.

With reference to Item 11 of the Report, the Honorary General Secretary gave an outline of the scope of the new monthly Bulletin *South African Science—Suid-Afrikaanse Wetenskap*, the first issue of which, containing messages of greeting from Field-Marshal the Right Honourable J. C. Smuts, Prime Minister of South Africa, and Dr. B. F. J. Schonland, President of the South African

Council for Scientific and Industrial Research, would appear in August, 1947. The Bulletin would be distributed free to members and would also be on sale to the public.

The President congratulated Dr. A. E. H. Bleksley, the Chairman of the Future Policy and Activities Committee, on the work his Committee had done in arranging for the issue of the new Bulletin, and also Dr. H. B. S. Cooke, the Editor of the Bulletin, who had the first number in hand.

Jaarverslag van die Raad vir die jaar tot op 30 Junie 1947.—Die Jaarverslag van die Raad vir die jaar eindigende 30 Junie, 1947 wat behoorlik op die kennisgewingsbord gepubliseer was is as gelees beskou en aangeneem.

Met verwysing na Item 11 van die Verslag het die Ere-Algemene Sekretaris 'n skets gegee van die omvang van die nuwe maandelikse Bulletin *South African Science—Suid-Afrikaanse Wetenskap,* die eerste deel waarvan in Augustus 1947 sou verskyn. Die eerste uitgawe sou boodskappe van Veld-Marskalk die Hoogedele J. C. Smuts, Eerste Minister van Suid-Afrika, en van Dr. B. F. J. Schonland, President van die Suid-Afrikaanse Raad vir Wetenskaplike en Industriële Navorsing. Die Bulletin sou kosteloos aan Lede verskaf word, en ook aan die publiek te koop aangebied word.

Die President het Dr. A. E. H. Bleksley, Voorsitter van die Komittee oor Toekomstige Beleid en Werksaamhede, gelukgewens met die werk wat die Komitee gedoen het in verband met die uitgawe van die nuwe Bulletin, asook Dr. H. B. S. Cooke, Redakteur van die Bulletin, wat die Eerste Deel van die Bulletin reeds in hande het.

4.—**Annual Report of the Honorary General Treasurer and Statement of Accounts for the year ended 31st May, 1947.**—The Honorary General Treasurer's Report and the Statement of Accounts for the year ended 31st May, 1947, having been duly displayed on the Notice Board, were taken as read and adopted.

Jaarverslag van die Ere-Algemene Penningmeester en Staat van Rekeninge vir die jaar eindigende 31 Mei 1947.—Die Jaarverslag van die Ere-Algemene Penningmeester en die Staat van Rekeninge vir die jaar eindigende 31 Mei 1947, wat behoorlik op die Kennisgewingbord gepubliseer is, is as gelees beskou en goedgekeur.

5. **Annual Report of the Honorary Librarian for the year ended 31st May, 1947.**—The Annual Report of the Honorary Librarian for the year ended 31st May, 1947, having been duly displayed on the Notice Board, was taken as read and adopted.

Jaarverslag van die Ere-Bibliotekaris vir die jaar eindigende 31 Mei 1947.—Die Jaarverslag van die Ere-Bibliotekaris vir die jaar eindigende 31 Mei 1947, wat behoorlik op die Kennisgewingbord gepubliseer is, is as gelees beskou en goedgekeur.

6. **Amendments to the Constitution.**—The President moved the adoption of the following amendments to the Constitution, which amendments had been approved by the Council in accordance with the provisions of Clause 40 of the Constitution :—

"That Clauses 20 and 21 of the Constitution be amended to read :—

Clause 20.—The Council shall consist of the President, four Vice-Presidents, two General Secretaries, the General Treasurer, the Editor-in-Chief of the Publications of the Association, the Journal Editor, the Bulletin Editor, and the Librarian, together with one member of the Council to every fifteen members of the Association. The immediate Past President shall be, ipso facto, a member of Council.

Clause 21.—The President, Vice-Presidents, General Secretaries, General Treasurer, the Editor-in-Chief of the Publications of the Association,

the Journal Editor, the Bulletin Editor, and the Librarian shall be nominated at a meeting of Council not later than two months previous to the Annual Session, and shall be elected at the Annual General Meeting."

Dr. G. de Kock and Dr. F. E. T. Krause raised the question of amending Clauses 20 and 22 of the Constitution to provide for one member of Council to every twenty members of the Association, instead of to every fifteen members, as is the present procedure, because, as a result of the considerable increase in membership during the past two years, the Council was becoming too large; to make provision for all Past Presidents to be "ipso facto" members of the Council; and to allow for Mozambique to be represented on the Council.

It was agreed that these suggestions be referred to the Council for consideration, after which the amendments to Clauses 20 and 21 of the Constitution, as shown above, were carried by the Meeting.

Amendmente tot die Konstitusie.—Die President het die goedkeuring van die volgende amendmente tot die Konstitusie voorgestel, amendemente wat in ooreenstemming met Klousule 40 van die Konstitusie deur die Raad goedgekeur is:—

Dat Klousules 20 en 21 van die Konstitusie amendeer word om te lees:—

Klousule 20.—Die Raad sal bestaan uit die President, vier Vice-Presidente, twee Algemene Sekretarisse, die Algemene Penningmeester, die Hoof-Redakteur van die Publikasies van die Genootskap, die Joernaal-Redakteur, die Bulletin-Redakteur, en die Bibliotekaris, tesame met een lid van die Raad vir elke vyftien lede van die Genootskap. Die onmiddellike Oud-President sal, ipso facto, lid van die Raad wees.

Klousule 21.—Die President, Vice-Presidente, Algemene Sekretarisse, Algemene Penningmeester, die Hoof-Redakteur van die Publikasies van die Genootskap, die Joernaal-Redakteur, die Bulletin-Redakteur, en die Bibliotekaris sal by 'n vergadering van die Raad nie later as twee maande voor die Jaarvergadering genomineer word, en sal by die Algemene Jaarvergadering gekies word.

Dr. G. de Kock en Dr. F. E. T. Krause het die vraag geopper om Klousules 20 en 22 van die Konstitusie te wysig sodat daar voorsiening gemaak word vir een lid van die Raad vir elke twintig lede van die Genootskap, inplaas van vir elke vyftien lede soos op die oomblik die geval is, omdat die Raad as gevolg van die groot toename in ledetal in die afgelope twee jaar nou te groot begin word. Verder, om daarvoor voorsiening te maak dat alle Oud-Presidente ipso facto lede van die Raad word, en om verteenwoordiging vir Moçambique op die Raad te verkry.

Dit is aangeneem dat die voorstelle vir oorweging na die Raad verwys sou word, waarna die amendemente tot Klousules 20 en 21 van die Konstitusie, soos hierbo aangegee, deur die Vergadering aangeneem is.

7 & 8:—Election of General Officers and Members of Council for 1947/1948.—The names of members elected as General Officers and members of the Council for the year 1947/48 are given on page ii.

It was noted that Dr. S. H. Skaife, who, unfortunately, had to visit Rhodesia for business reasons, had expressed his regret at being unable to attend this meeting.

The President referred to the retirement of Professor John F. V. Phillips from the office of Honorary Editor, which had been occasioned through his present heavy commitments: it was agreed to place on record the Association's indebtedness to Professor Phillips for his past services.

Dr. G. de Kock proposed a hearty vote of thanks to Mr. S. B. Asher for the valuable work he had done in editing the Journal. This vote of thanks was supported by the President, who stated how much the Association appreciated the fact that, in his new capacity as Honorary Journal Editor, Mr. Asher would continue to edit the Journal during the coming year, after which the vote of thanks was carried by acclamation.

Verkiesing van Algemene Ampsdraers en Raadslede vir 1947/48.—Die name van die lede wat tot Algemene Ampsdraers en Raadslede vir die jaar 1947/48 gekies is word op bladsy ii aangegee.

Dit is genoteer dat Dr. S. H. Skaife, wat ongelukkig vir sake na Rhodesië moes gaan, sy spyt te kenne gegee het dat hy nie in staat was om die Vergadering by te woon nie.

Die President het verwys na die aftrede van Professor John F. V. Phillips uit die amp van Ere-Redakteur, as gevolg van sy ander bedrywighede; dit is besluit om die waardering van die Genootskap vir die dienste van Professor Phillips te notuleer.

Dr. G. de Kock het 'n hartlike mosie van dank aan Mnr. S. B. Asher voorgestel, vir die waardevolle dienste wat hy met die redigeer van die Joernaal gelewer het. Die mosie van dank is deur die President ondersteun; in sy aanmerkings het die President gemeld hoe seer die Genootskap die feit appresieer dat Mnr. Asher, in sy nuwe hoedanigheid as Joernaal-Redakteur, sal aanhou om die Joernaal in die komende jaar te redigeer. Daarna is die mosie van dank met applous aangeneem.

9. **Resolutions from Sections C and D:**

(a) **Protection and Control of the Fauna, Flora and Sanctuaries of South Africa.**—"That this Congress expresses its appreciation of the action taken by the Minister of Lands in authorising the establishment of a Scientific Advisory Council for National Parks and Nature Reserves. The Association urges that early steps be taken to bring this council into operation according to the Constitution already drawn up.

The South African Association for the Advancement of Science would appreciate a reference by the Minister of the following matter to the Advisory-Council-to-be-appointed:

That, in view of the inadequacy of the existing Cape Mountain Zebra National Park, a park should be established in the Outeniqua Mountains, where zebra still exist in adequate numbers.

This Outeniqua National Park should, at the same time, be conceived on a large scale for the general protection of the water resources, for the preservation of the other fauna, the scenery and the flora typical of the Cape mountain ranges (for which, thus far, no provision has been made) and for the enjoyment and education of the people.",

(b) **The Tsetse Fly Problem of Southern Africa.**—"This Congress, having regard to the promising results achieved in dealing with the tsetse fly menace in South Africa, by means of the application of DDT, bush clearing and other measures, hereby expresses its deep appreciation of the latest measures adopted by the Department of Agriculture, and urges upon the Government to spare no means whereby a halt may be called at the earliest possible opportunity to the destruction of our game.

This Congress urgently requests the Provincial authorities more strictly to enforce the laws relating to the protection and conservation of our wild life, both flora and fauna."

(c) **Letters of Appreciation.**—The combined session of Sections C and D recommends that letters of appreciation be written

(i) to the Administrator of the Transvaal for the action taken in implementing the recommendations of the Transvaal Game Commission, especially in regard to the appointment of a Director of Inland Fisheries and of a Conservator of the Fauna and Flora ;

(ii) to the Transvaal Provincial Secretary for his excellent chairmanship of the Game Commission, and for the constructive action he has taken.

(d) **Delivery of Papers.**—Sections C and D submit the following suggestion for consideration by Council :—

"That, since the value of a paper to the members of any section lies as much in the discussion as in the reading of the paper, it is recommended that the contributor be present at the meeting, or that he/she be represented by someone qualified to speak on his/her behalf."

(e) **Summaries of Papers.**—Section D submits this suggestion for consideration by Council :—

"That a short summary of all papers to be read at the Annual Meeting be circulated to all members (sectional) who will be attending the Session."

Proposed by Dr. G. de Kock.
Seconded by Dr. E. C. N. van Hoepen.

(f) **Staffing of Government Research Departments.**—At a combined meeting of Sections C and D it was resolved to submit the following resolution for consideration by Council (with a view to taking the necessary action, if deemed advisable) :

"That this Association is very much concerned at the shortage of trained scientists available for the staffing of the Technical Divisions in Government Research Departments, more particularly in those Divisions carrying out research work on biological and agricultural problems, and would like to stress the need for making conditions in the Government service more attractive to young scientists."

The above resolutions were adopted and referred to the Council for action

Besluite van Afdelings C en D :

(a) **Beskerming en Beheer van die Fauna, Flora, en Sanctuaria van Suid-Afrika :—**

„Dat die Vergadering sy waardering uitspreek oor die aksie wat deur die Minister van Lande geneem is, deur die stigting van 'n Wetenskaplike Adviserende Raad vir Nasionale Parke en Natuur Reserwes te magtig. Die Genootskap beveel aan dat vroeë stappe geneem word om die Raad in werking te bring na aanleiding van die Konstitusie wat reeds opgetrek is.

Die Suid-Afrikaanse Genootskap vir die Bevordering van Wetenskap sou dit waardeer as die Minister die volgende saak aan die Raad wat aangestel sal word wil voorlê :

Dat, aangesien die bestaande Kaapse Berg-Zebra Nasionale Park ontoereikend is, 'n park in die Outeniquaberge gestig behoort te word, waar daar nog zebra in toereikende getalle voorkom.

Die Outeniqua Nasionale Park behoort dan terselfdertyd op groot skaal voorgestel word, om die watervoorrade in die algemeen te beskerm, om die ander fauna te behou, asook vir die behoud van die natuurskoon en die flora van die Kaaplandse bergreekse (waarvoor daar tot dusver geen voorsiening gemaak is nie), en vir die genot en opvoeding van die volk."

(b) **Die Tsetsevlieg Probleem van Suidelike Afrika**:

„Die Vergadering, in ag nemende die belowende resultate wat deur die toepassing van DDT, die opruiming van bosstreke, en ander metodes behaal is, spreek sy diepe waardering uit oor die nuutste metodes wat deur die Landbou Department toegepas is, en sou graag wil aanbeveel dat die Regering geen steen onaangeroerd laat om so vroeg moontlik 'n einde te bring aan die vernietiging van ons wild.

Die Vergadering doen 'n dringende beroep op die Provinsiale outoriteite om die wette in verband met die beskerming en behoud van ons inheemse fauna en flora meer streng uit te voer.''

(c) **Briewe van Waardering.**—„Die gesamentlike sitting van Afdelings C en D beveel aan dat briewe van waardering gerig word aan

(1) die Administrateur van die Transvaal vir die stappe wat geneem is om die aanbevelings van die Transvaalse Wild Kommissie aan te vul, in die besonder deur die aanstelling van 'n Direkteur van Binnelandse Visserye en van 'n Konservator vir die Fauna en Flora;

(ii) die Provinsiale Sekretaris vir Transvaal vir sy uitstekende Voorsitterskap van die Wild Kommissie, en vir sy konstruktiewe handeling.

(d) **Voordra van Verhandelings.**—Afdelings C en D lê die volgende aanbeveling voor vir oorweging deur die Raad:—

„Dat, aangesien die waarde van 'n verhandeling vir die lede van 'n afdeling eweveel in die daaropvolgende bespreking lê as in die lees daarvan, dit aanbeveel word dat die skrywer by die Vergadering teenwoordig moet wees, of dat hy/sy deur 'n persoon verteenwoordig sal wees wat bevoeg is om namens hom/haar te praat.''

(e) **Opsommings van Verhandelings.**—Afdeling D lê die volgende aanbeveling voor vir oorweging deur die Raad:—

„Dat 'n kort opsomming van alle verhandelings wat by die Jaarvergadering gelees sal word aan alle lede (Afdelings-) wat die Vergadering bywoon omgestuur word.''

Voorgestel deur Dr. G. de Kock.
Gesekondeer deur Dr. E. C. N. van Hoepen.

(f) **Personeel van Regerings Navorsingsdepartemente.**—By 'n gesamentlike byeenkoms van Afdelings C en D is besluit om die volgende mosie vir oorweging deur die Raad voor te lê (met die oog op die nodige aksie, indien wenslik geag):—

„Dat die Genootskap baie begaan is oor die tekort aan opgeleide wetenskaplikes wat vir aanstelling op die personeel van die Tegniese Afdelings in Regerings Navorsingsdepartemente beskikbaar is, meer bepaald in die Afdelings wat navorsings in biologiese en landboukundige probleme uitvoer, en wil graag klem lê op die noodsaaklikheid daarvan dat toestande in die Regeringsdiens meer aantreklik vir jong wetenskaplikes gemaak moet word.''

Bogemelde besluite is aangeneem en na die Raad vir handeling verwys.

10. **Annual Meeting, 1948.**—The President reported that the Council had accepted the invitation from the Sociedade de Estudos da Colonia de Moçambique to hold the 1948 Annual Meeting in Lourenco Marques and said that he had great pleasure in welcoming Dr. L. A. Barradas, Dr. J. de O. Boléo and Professor A. Quintanilha, the Sociedade's representatives at this meeting.

At the invitation of the President, Professor Quintanilha addressed the meeting, stating that the Sociedade looked forward to welcoming the Association next year and would do everything possible to make the meeting a success.

It was necessary that the dates for the meeting should be fixed well in advance to enable members to make their hotel reservations at least three months beforehand, as there was a great shortage of accommodation in Lourenço Marques.

Jaarvergadering, 1948.—Die President het aangekondig dat die Raad die uitnodiging van die Sociedade de Estudos da Colonia de Moçambique om die Jaarvergadering in 1948 in Lourenço Marques te hou aangeneem het, en het bygevoeg dat dit hom groot genoeë gee om Dr. L. A. Barradas, Dr. J. de O. Boléo, en Professor A. Quintanilha, die verteenwoordigers van die Sociedade by die huidige Vergadering, te verwelkom.

Op uitnodiging van die President het Professor Quintanilha die Vergadering toegespreek. Hy het verklaar dat die Sociedade daarna uitsien om die Genootskap aanstaande jaar te kan verwelkom, en alles sou doen om 'n sukses van die byeenkoms te maak. Dit is noodsaaklik dat die datum van die byeenkoms heel vroegtydig vasgestel word sodat lede minstens drie maande vroeër hul hotelbesprekings kan maak, aangesien daar 'n groot tekort aan akkommodasie in Lourenço Marques bestaan.

11. **South Africa Medal.**—Dr. A. L. du Toit drew attention to the fact that for the past two years and on several occasions in the past no nominations for the award of the South Africa Medal had been received. He asked the Council to consider the question of amending the procedure for the nomination of recipients of the Medal, as laid down in Clause 41 of the Constitution, so that the non-award of the Medal should not be the result of an oversight on the part of members.

Suid-Afrika Medalje.—Dr. A. L. du Toit het aandag daarop gevestig dat daar in die afgelope twee jaar, asook op verskeie geleenthede in die verlede, geen nominasies vir die toekenning van die Suid-Afrika Medalje ontvang is nie. Hy het die Raad versoek om die moontlikheid van 'n verandering in die prosedure vir die nominasie van ontvangers van die Medalje soos in Klousule 41 van die Konstitusie neergelê te oorweeg, om te verhoed dat die toekenning van die Medalje nie as gevolg van versuim aan die kant van lede in gebreke bly nie.

12. **Votes of Thanks.**—On the proposal of Professor John Orr, a unanimous vote of thanks was accorded to the following:—

To His Worship the Mayor (Councillor H. H. Steyn) and the Town Council of Oudtshoorn, for inviting the Association to hold its meeting in Oudtshoorn and for the hospitality received, and to the Town Clerk of Oudtshoorn (Mr. G. W. van Rooyen) and his staff for the work they had done in this connection.

To the Local Committee for the excellent arrangements made for the meeting.

To the Principal (Mr. I. J. M. Archer) and the School Committee of the Boys' High School for providing accommodation for the meeting.

To the Postmaster of Oudtshoorn for providing a telephone and postal facilities at the Boy's High School for the meeting.

To the Women's Methodist Auxiliary, the West Bank Vroue Landbou Vereniging, the Union of Jewish Women, the Oudtshoorn Women's Association and the Afrikaanse Christelike Vroue Vereniging for arranging the morning and afternoon teas.

To the Amateur Dramatic Society and the other artists for the programme at the Civic Reception, the Horticultural Society for the floral decorations, and the National Council of Women for providing refreshments at the reception.

To the Town Electrical Engineer (Mr. C. Adams) for assisting with alterations to the electrical system in the Drill Hall to provide for the projection of cinematograph films.

To the University of the Witwatersrand for lending the Association a sixteen millimetre sound projector.

To Dr. A. L. du Toit for collecting the Bushman drawings and the topographical maps of Oudtshoorn and the district to the East which were exhibited at the meeting.

To the ladies and gentlemen who kindly provided transport for the excursions, and to Mr. Max Rose for distributing ostrich feathers as souvenirs to the members who visited his farm.

To Mrs. Johan le Roux, Mrs. Sydney van Niekerk, Mrs. Pieter P. Schoeman, Mrs. E. Warren and Mrs. du Plessis for providing afternoon tea during the excursions.

For privileges of honorary membership during the session to:

the Oudtshoorn Lawn Tennis Club,
the Croquet Club,
the Bowling Club, and
the Golf Club.

To the Press for reporting papers read at the meeting.

To the Vice-Presidents, the Honorary General Secretaries, the Honorary General Treasurer and the Honorary Librarian for the work they had done during the past year.

To the Assistant General Secretaries for the efficient manner in which they had performed their duties.

To the Honorary Auditors (Messrs. Alex. Aiken and Carter) for their services in carrying out the audit for the year 1946/1947.

Dr. F. E. T. Krause proposed a hearty vote of thanks to the President, Professor H. H. Paine, for the services he had rendered the Association during his term of office, this vote of thanks being accorded with acclamation.

The President, in acknowledging Dr. Krause's remarks, expressed his appreciation of the support he had received from the Officers of the Association and from the Council and of the warm welcome which had been given to the Association by the Mayor and citizens of Oudtshoorn.

This concluded the business and the meeting terminated at 12.30 p.m.

Mosies van Dank.—Op voorstel van Professor John Orr is 'n eenparige mosie van dank aan die volgende persone aangeneem :—

Aan Sy Edelagbare die Burgemeester (Raadslid H. H. Steyn) en die Stadsraad van Oudtshoorn vir hul uitnodiging aan die Genootskap om die Jaarvergadering in Oudtshoorn te hou asook vir die gasvryheid wat ontvang is, en aan die Stadsklerk van Oudtshoorn (Mnr. G. W. van Rooyen) en sy staf vir die werk wat hulle in dié verband gedoen het.

Aan die Plaaslike Komitee vir die uitstekende reëlings wat vir die vergadering getref is.

Aan die Prinsipaal (Mnr. I. J. M. Archer) en die Skoolkomitee van die Hoër Jongenskool vir die verskaffing van akkommodasie vir die vergadering.

Aan die Posmeester van Oudtshoorn vir die verskaffing van 'n telefoon en posfasiliteite by die Hoër Skool vir die vergadering.

Aan die Women's Methodist Auxiliary, die Wes Bank Vroue Landbouvereniging, die Union of Jewish Women, die Oudtshoorn Vroue Vereniging, en die Afrikaanse Christelike Vroue Vereniging vir die reëling van oggend- en middagtee.

Aan die Amateur Dramatiese Vereniging en die ander artiste vir die program by die Burgelike Ontvangs, die Tuinbouvereniging vir die blommeversiering, en die Nasionale Vroue Raad vir die verskaffing van verversings by die ontvangs.

Aan die Stads Elektriese Ingenieur (Mnr. C. Adams) vir sy hulp met die verandering van die elektriese installasie in die Drilsaal om die projeksie van rolprente moontlik te maak.

Aan die Universiteit van die Witwatersrand vir die lening van 'n sestien millimeter klank projektor.

Aan Dr. A. L. du Toit vir die versameling van Boesmantekenings en topografiese kaarte van Oudtshoorn en die distrik na die Ooste wat by die vergadering vertoon is.

Aan die dames en here wat welwillend voertuie vir die uitstappies verskaf het, en aan Mnr. Max Rose vir die uitdeling van volstruisvere as soeweniers aan die lede wat sy plaas besoek het.

Aan Mev. Johan le Roux, Mev. Sydney van Niekerk, Mev. Pieter P. Schoeman, Mev. E. Warren, en Mev. du Plessis, vir die verskaffing van middagtee gedurende die uitstappies.

Vir die voorregte van Ere-lidmaatskap gedurende die vergadering aan :—

Die Oudtshoorn Tennis Klub,
Die Croquet Klub,
Die Rolbalklub,
Die Gholfklub.

Aan die Pers vir verslae oor verhandelings by die vergadering.

Aan die Vice-Presidente, die Ere-Algemene Sekretarisse, die Ere-Algemene Penningmeester en die Ere-Bibliotekaris vir die dienste wat hulle gedurende die afgelope jaar gelewer het.

Aan die Assistent-Algemene Sekretarisse vir die doeltreffende wyse waarop hulle hul pligte verrig het.

Aan die Ere-Ouditeure (die firma Alex. Aiken en Carter) vir hul dienste in die uitvoering van die ouditering vir die jaar 1946/47.

Dr. F. E. T. Krause het 'n hartelike mosie van dank aan die President, Professor H. H. Paine, vir sy dienste aan die Genootskap gedurende sy ampsjaar voorgestel; die mosie van dank is met toejuiging aangeneem.

In sy bedankingswoorde aan Dr. Krause, het die President sy waardering uitgespreek oor die ondersteuning wat hy van die Ampsdraers van die Genootskap en van die Raad ontvang het, en ook vir die warme welkom wat die Genootskap van die Burgemeester en burgers van Oudtshoorn ontvang het.

Hiermee is die verrigtings afgesluit, en die vergadering het om 12.30 n.m. geëindig.

REPORT OF COUNCIL FOR THE YEAR ENDING 30TH JUNE, 1947.
VERSLAG VAN DIE RAAD VIR DIE JAAR EINDIGENDE 30 JUNIE, 1947.

1. **Obituary.**—Your Council reports with regret the death of the following members :—

In Memoriam.—U Raad gee met leedwese kennis van die oorlyde van die volgende lede :—

Sir J. Carruthers Beattie, Professor A. Brown, Mr. W. A. J. Cameron, Mr. G. Imroth, Mr. W. R. Owens, Professor M. M. Rindl, Dr. J. B. Robertson, Mr. T. Ambler-Smith, Mr. J. Lyall Soutter, Dr. H. van Gent, Mr. J. H. E. Wilson.

2. **Membership.**—Since the last report, eighty-five members have joined the Association, eleven have died, ten have resigned and the names of three members have been removed from the Membership List, in accordance with the provisions of Clause 7 of the Constitution.

The following table shows a comparative list of the geographical distribution of membership as at the 30th June, 1946 and the 30th June, 1947 :—

Ledetal.—Sedert die jongste verslag het vyf-en-tagtig lede by die Genootskap aangesluit, elf is oorlyde, tien het bedank, en die name van drie is van die Ledelys afgekrap volgens die bepalings van Klousule 7 van die Konstitusie.

Die volgende lys toon, vergelykenderwys, die geografiese voorkoms van lede op 30 Junie 1946 en 30 Junie 1947 :—

	1946	1947
Transvaal	473	508
Cape of Good Hope	162	187
Natal	79	79
Orange Free State	23	23
Southern and Northern Rhodesia	14	13
South-West Africa	1	1
Mozambique	3	3
Abroad	29	31
	784	845

3. **The Journal.**—It is regretted that Volume XLIII of the *South Africon Journal of Science*, being the Annual Report of the Association for the year ended 30th June, 1946, will only be circulated to members in July, 1947.

Die „Joernaal."—Dit spyt ons dat Deel XLIII van die *Suid-Afrikaanse Joernaal van Wetenskap*, synde die verslag van die Raad vir die jaar eindigende 30 Junie 1946 nie voor Julie, 1947 aan lede uitgegee sal wees nie.

4. **Bulletin.**—One bulletin was issued in the year under review, in June, 1947.

Een Bulletin is gedurende die jaar onder oorsig uitgegee, naamlik in Junie, 1947.

5. **South Africa Medal and Grant, 1947.**—No award was made.

Suid-Afrika Medalje en Skenking, 1947.—Geen toekenning is gedoen nie.

6. **British Association Medal, 1947.**—No award.

Britse Genootskapsmedalje, 1947.—Geen toekenning.

7. **Donations.**—The thanks of the Association are due to the Honourable the Minister of Finance and of Education for a grant of £250 towards the expenses of the publication of the Journal, and to the Johannesburg Municipality for a grant of £100.

Donasies.—Die Genootskap spreek sy dank uit aan Sy Ed. die Minister van Finansies en van Onderwys vir 'n donasie van £250 tot die onkoste van di Joernaal, en aan die Johannesburgse Munisipaliteit vir 'n toelae van £100.

Resolutions Adopted by Annual General Meeting, 5th July, 1946:

(a) **Teaching of Biology in South African Schools.**—A sub-committee was appointed to prepare, with members of a committee appointed by the South African Biological Society, a report suggesting how the provisions of the Resolution might best be brought into effect.

(*b*) **By-Products from Wool Washeries.**—A letter embodying this resolution was sent to the Council for Scientific and Industrial Research.

(c) **The Milk Industry in South Africa.**—Letters embodying this resolution were sent to the Ministers of Public Health and Agriculture.

(d) **Protection and Control of the Fauna, Flora and Sanctuaries of South Africa.**—Following representations by the Association, a meeting of all interests concerned in this matter took place with the Minister of Lands, who then convened a conference at which the various problems were very fully discussed.

(e) **Disappearance of Wild Life Along River Courses in South Africa.**—This matter was raised in the Conference referred to in (d) above.

(f) **Surface and Underground Water supplies in South Africa.**—Letters embodying this resolution were sent to the Department of Irrigation and to the Geological Survey.

Besluite Aangeneem deur die Algemene Jaarvergadering, 5 Julie, 1946.

(a) **Die Onderwys van Biologie in Suid-Afrikaanse Skole.**—'n Onderkomitee is aangestel om, tesame met lede van 'n komitee wat deur die Suid-Afrikaanse Biologiese Vereniging aangestel is, voorstelle te doen insake die stappe wat geneem moet word om die bepalings van die besluit aan te vul.

(b) **By-produkte uit Wolwasserye**—'n Brief wat die besluit bevat is aan die Raad vir Wetenskaplike en Industriële Navorsing gestuur.

(c) **Die Melk-Industrie in Suid-Afrika.**—Briewe wat die besluit bevat is aan die Ministers van Volksgesondheid en Landbou gestuur.

(d) **Beskerming en beheer van die fauna, flora, en sanctuaria in Suid-Afrika.**—Volgende op vertoë deur die Genootskap, is 'n vergadering van alle belangstellende liggame met die Minister van Lande gehou. Daarna het die Minister 'n konferensie belê by welke geleentheid die verskeie probleme vollediglik bespreek is.

(e) **Verdwyning van fauna langs rivierlope in Suid-Afrika.**—Die saak is ook by die konferensie in (d) vermeld te berde gebring.

(f) **Oppervlakte-en-Ondergrondse-Watervoorrade in Suid-Afrika.**—Briewe wat die besluit bevat is aan die Besproeiings departement en die Geologiese Opname gestuur.

9. **Loyal Address to his Majesty King George VI.**—The Council submitted a Loyal Address to His Majesty the King, patron of the Association. A letter was received from the Private Secretary, expressing the King's appreciation at receipt of the Address.

Lojale Boodskap aan Sy Majesteit Koning George VI.—Die Raad het 'n Lojale Boodskap aan Sy Majesteit die Koning, beskermheer van die Genootskap gestuur. 'n Brief is van die Privaat Sekretaris ontvang, waarin die Koning sy genot met die ontvangs van die Boodskap uitdruk.

10. **Future Policy and Activities of the Association.**—A committee of the Council was appointed to consider the future policy and activities of the Association. Among the matters dealt with by the Committee were the institution of a Press panel, the organisation in Johannesburg of two series of popular lectures to the public and to pupils of High Schools, and a change in the publication policy of the Association, the latter being dealt with more fully in (11) below.

Toekomstige beleid en Aktiwiteite van die Genootskap.—'n Komitee is deur die Raad aangestel om in te gaan op die toekomstige beleid en Aktiwiteite van die

Genootskap. Onder die sake wat deur die komitee behandel is, is die stigting van 'n paneel om met die Pers saam te werk, die organisasie van twee reekse populêre voorlesings aan die publiek en aan die skoliere van Hoërskole, en 'n verandering in die publikasie beleid van die Genootskap, laasgenoemde waarvan in groter besonderhede in (11) behandel word.

11. **Publications of the Association.**—The Council has accepted a change in the policy with regard to publications, according to which the Journal is to be reduced in bulk and at the same time improved in quality by publishing in full only such papers as specially merit such publication, all other papers read at the Annual Meeting to be published in brief abstract only. At the same time, the Bulletin is to be expanded into a monthly publication to be called *South African Science—Suid-Afrikaanse Wetenskap*, to contain reports and reviews on current science, notes on research, and other material of scientific and general value. The first issue of the new monthly will appear in August, 1947.

Publikasies van die Genootskap.—Die Raad het 'n verandering in die beleid van die Genootskap insake sy publikasies goedgekeur, waarvolgens die „Journal" wat sy grootte betref verminder sal word, terwyl die gehalte van sy inhoud verhoog word, deur slegs lesings ten volle te publiseer wat sodanige publikasie op besondere wyse regverdig, terwyl alle ander lesings wat by die Jaarlikse Byeenkoms voorgedra word slegs in die vorm van verkorte opsommings gepubliseer sal word. Terselfdertyd sal die Bulletin in 'n maandblad uitgebrei word, onder die titel *South African Science—Suid-Afrikaanse Wetenskap*, wat verslae en oorsigte oor huidige wetenskap, notas oor navorsing, en ander materiaal van wetenskaplike en algemene waarde sal bevat. Die eerste uitgawe van die nuwe blad sal in Augustus 1947 die lig sien.

12. **Annual Meeting, 1947.**—The Annual Meeting for 1947 has been arranged to take place in Oudtshoorn from 30th June to 4th July, 1947.

Jaarvergadering, 1947.—Reëlings is getref om die Jaarvergadering in Oudtshoorn, van 30 Junie tot 4 Julie 1947, te hou.

13. **The New Council.**—On the basis of membership provided in the Constitution, Section 22, the number of members of Council assigned to each centre during the ensuing year should be as follows:—

Die Nuwe Raad.—Die aantal Raadslede vir elke sentrum gedurende die volgende jaar, moet, soos in die Statute, Artikel 22, bepaal, op die basis van die ledetal as volg verdeel word.—

Transvaal:	
Witwatersrand	22
Pretoria	10
Outside Districts/Buitedistrikte	2
Province of the Cape of Good Hope:	
Cape Peninsula and District/en Distrik	6
Stellenbosch and District/en Distrik	2
East London and Port Elizabeth	1
Grahamstown and Kingwilliamstown and District/en Distrik	1
Kimberley	1
Oudtshoorn	2
Outside Districts/Buitedistrikte	1
Natal:	
Durban and District/en Distrik	3
Pietermaritzburg and Outside Districts/en Buitedistrikte	2
Orange Free State:	
Bloemfontein and District/en Distrik	2
Southern Rhodesia	1
	56

14. **Honorary Auditors.**—The thanks of the Association are again due to Messrs. Alex. Aiken & Carter, the Honorary Auditors, who have audited the Accounts of the Association for 1946/1947.

Ere-Ouditeure.—Die Genootskap is weer dank verskuldig aan die firma Alex. Aiken & Carter, die Ere-Ouditeure, wat die Rekeninge van die Genootskap vir 1946/1947 geouditeer het.

15. **Secretariat.**—The Council tenders its thanks to the Associated Scientific Societies for their services as Assistant General Secretaries of the Association throughout the year, and expresses its appreciation of the unfailing help given by Mr. A. J. Adams and Mr. I. M. Sinclair.

Sekretariaat.—Die Raad bring sy dank aan die Verenigde Wetenskaplike en Werktuigkundige Vereniginge vir hulle dienste as Assistent-Algemene Sekretarisse van die Genootskap gedurende die jaar, en spreek sy waardering uit vir die getroue hulp wat Mnr. A. J. Adams en Mnr. I. M. Sinclair verleen het.

Report of the Honorary General Treasurer for the Year ended 31st May, 1947.

The result of the year's working shows a loss of £239 as compared with an excess of income over expenditure last year of £134. This is due to an increase of £502 in the nett cost of printing the *South African Journal of Science.* It was anticipated when the Editorial Committee discussed the printing of the Journal at the beginning of the year that not only would there be a reduction in cost but that it would be distributed to members earlier than has been customary of late years. These hopes have not been fulfilled.

One gratifying feature is that there has been an increase in revenue from subscriptions amounting to £209, which reflects the increasing interest being taken in the Association. It is hoped that the new policy to be adopted in connection with printing contributions received at Annual Meetings, through the medium of the Journal and Bulletin, will be successful and enhance the prestige of the Association.

It has been recognised for many years that funds have been used for printing in the Journal some contributions which were mediocre or repetitive and that the monies used for this purpose might well have been used for furthering the objects of the Association in other directions.

Thanks must be expressed to the Union Department of Education and to the Johannesburg City Council for their continued donations towards the cost of printing the Journal.

JAS. GRAY,
Honorary General Treasurer.

Verslag van die Ere-Algemene Penningmeester vir die jaar tot op 31 Mei 1947.

Die uitslag van die jaar se werksaamhede toon 'n verlies van £239 in vergelyking met 'n batige saldo van £134 verlede jaar. Dit is te wyte aan 'n vermeerdering van £502 in die koste in verband met die druk van die *Suid-Afrikaanse Joernaal van Wetenskap.* Toe die Redaksie Komitee vroeër in die jaar die druk van die Joernaal bespreek het, is die hoop gekoester dat daar nie alleen 'n vermindering in die koste sou wees nie, maar ook dat die Joernaal vroeër as in die afgelope aantal jare aan lede afgelewer sou kan word. Hierdie verwagtings is egter nie verwesenlik nie.

Een bevredigende kenmerk is die feit dat daar 'n toename van £209 in die inkomste uit ledefooie te bespeur is, wat daarop wys dat daar hernuwe belangstelling in die Genootskap gestel word. Daar word gehoop dat die nuwe beleid insake die publikasie van artikels in die Joernaal en die Bulletin suksesvol sal wees, en die reputasie van die Genootskap verder sal uitbrei.

Dit is reeds vir baie jare besef dat fondse bestee is vir die uitgee in die Joernaal van bydraes van middelmatige standaard, en dat die geld wat vir dié doel gebruik is met vrug gebruik kon gewees het om die oogmerke van die Genootskap in ander rigtings te bevorder.

Dank moet uitgespreek word aan die Unie-Departement van Onderwys en aan die Stadsraad van Johannesburg vir die voortsetting van hulle bydrae, by wyse van skenkinge, tot die drukkoste van die Joernaal.

JAS. GRAY,
Ere-Algemene Penningmeester.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

BALANCE SHEET AT 31st MAY, 1947.

LIABILITIES.

	£ s. d.	£ s. d.
Sundry Creditors:		
General Accounts.	1,233 11 11	
Grants to Local Centres under Rule 35. ..	55 10 0	
Subscriptions paid in Advance	44 0 0	1,333 1 11
Library Binding and Equipment Account:		
Balance at 31st May, 1946	303 8 2	
Add Interest from Library Endowment Fund.	73 17 11	
	377 6 1	
Less Expenditure during the year ..	63 3 2	314 2 11
Income and Expenditure Account:		
Balance at 31st May, 1946	576 19 0	
Less Excess of Expenditure over Income for the year ended 31st May, 1947 ..	239 13 9	337 5 3
		1,984 10 1
Endowment Fund		3,387 14 5
Library Endowment Fund		2,164 11 6
South Africa Medal Fund		1,755 18 5
British Association Medal Fund		544 16 3
		£9,837 10 8

ASSETS.

Cash:		
At Bank	855 12 6	
At Post Office Savings Bank with Interest accrued	42 17 10	
At United Building Society, St. Andrew's accrued	1,007 8 11	1,905 19 3
Sundry Debtors:		
Endowment Fund	14 11 11	
Library Endowment Fund	3 17 11	
Advertisers in Journal	44 15 0	63 4 10
Furniture		
Balance at 31st May, 1946	17 0 0	
Less Depreciation	3 10 0	13 10 0
Medals on Hand		1 16 0
		1,984 10 1
Trustees—Endowment Fund, As per separate account		3,387 14 5
Library Endowment Fund, as per separate account		2,164 11 6
Trustees—South Africa Medal Fund, as per separate account ..		1,755 18 5
Trustees—British Association Medal Fund, as per separate account		544 16 3
		£9,837 10 8

We have examined the books, accounts and vouchers of The South African Association for the Advancement of Science for the year ended 31st May, 1947 and have obtained all the information and explanations we have required. We have satisfied ourselves of the existence of the securities. Proper books and accounts have been kept. In our opinion the above Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of affairs of the Association at 31st May 1947, according to the best of our information and the explanations given to us and as shown by the books of the Association as at 31st May, 1947.

Johannesburg.

24th June, 1947.

ALEX. AIKEN & CARTER,

Auditors.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY, 1947.

Dr.

	£ s. d.	£ s. d.	£ s. d.
To Secretarial Fees			290 0 0
„ Journal Expenses		1,274 10 8	
Less Government Grant ..	£250 0 0		
Johannesburg Municipal Grant	100 0 0		
Sales, Reprints and Advertisements	145 8 0		
		495 8 0	
			779 2 8
„ Stationery and Printing			89 2 9
„ Postages			37 5 5
„ Expenses: Annual Meeting 1946 (balance)			12 18 7
„ General Expenses			56 16 3
„ Grants to Local Centres under Rule 35:			
Witwatersrand	39 6 0		
Cape of Good Hope	10 1 0		
Natal	6 3 0		
		55 10 0	
Less Grant outstanding for Natal Centre for the year ended 31st May, 1946, not claimed		5 5 0	
			50 5 0
„ Depreciation on Office Furniture			3 10 0
„ Pension—H. A. G. Jeffreys			90 0 0
			£1,409 0 8

Cr.

	£ s. d.	£ s. d.
By Annual Subscriptions	911 5 0	
„ Arrear Subscriptions	60 12 0	
„ Associates' Fees	32 0 0	
„ Students' Fees	10 10 0	
		1,014 7 0
„ Interest: From Endowment Fund	134 4 5	
United Building Society, St. Andrew's Branch, Savings Account	19 14 11	
„ Post Office Savings Bank Account	1 0 7	
		154 19 11
„ Balance, being excess of Expenditure over income for the year ended 31st May, 1947		239 13 9
		1,409 0 8

We report that, to the best of our knowledge and belief and on the information supplied to us, the above account reflects a true statement of the income and expenditure of the Association for the year ended 31st May, 1947.

Johannesburg,
24th June, 1947.

ALEX. AIKEN & CARTER,
Auditors.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

LIBRARY ENDOWMENT FUND.

Dr. INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY, 1947 Cr.

	£ s. d.		£ s. d.
To Balance, transferred to Library Binding and Equipment Account	73 17 11	By Interest Received	73 17 11
	£73 17 11		£73 17 11

BALANCE SHEET AT 31st MAY, 1947.

	£ s. d.		£ s. d.	£ s. d.
Amount due to General Fund	3 17 11	Investments :		
Accumulated Funds :		£2,000 City of Johannesburg 3½% Local Registered Stock 1965—at cost	1,970 0 0	
Balance at 31st May, 1946	2,164 11 6	United Building Society, St. Andrew's Branch—Savings Account ..	198 9 5	
				2,168 9 5
	£2,168 9 5			£2,168 9 5

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

ENDOWMENT FUND.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY, 1947

Dr.	£ s. d.	£ s. d.	Cr.	£ s. d.
To Interest, as per contra, transferred to General Fund		134 4 5	By Interest Received	134 4 5
,, Balance, transferred to Accumulated Funds ..		9 0 0	,, Life Membership Subscriptions	9 0 0
		£143 4 5		£143 4 5

BALANCE SHEET AT 31st MAY, 1947.

	£ s. d.	£ s. d.		£ s. d.	£ s. d.
Amount due to General Fund ..		14 11 11	Investments in hands of Trustees :		
Accumulated Funds :			Cape Town Municipality 3¾% Stock—No. 145	1,150 0 0	
Balance at 31st May, 1946 ..	3,378 14 5		Cape Town Municipality 4% Stock—No. 140	300 0 0	
Add Amount transferred from Income and Expenditure Account ..	9 0 0	3,387 14 5	Cape Town Municipality 5% Stock—No. 68	240 0 0	
			Cape Town Municipality 5% Stock—No. 120	800 0 0	
			Port Elizabeth Municipality 3½% Stock—No. 9	100 0 0	
			Cape of Good Hope Savings Bank	812 6 4	3,402 6 4
		£3,402 6 4			£3,402 6 4

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

BRITISH ASSOCIATION MEDAL FUND.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY, 1947

Dr.	£ s. d.	Cr.	£ s. d.
To Award	10 0 0	By Interest received	18 19 7
,, Balance transferred to Accumulated Funds ..	8 19 7		
	£18 19 7		£18 19 7

BALANCE SHEET AT 31st MAY, 1947.

	£ s. d.	£ s. d.		£ s. d.	£ s. d.
Accumulated Funds:			Investments in hands of Trustees:		
Balance at 31st May, 1946 ..	535 16 8		£450 Union of South Africa $3\frac{3}{4}$% local Registered Stock, 1948/58	450 0 0	
Add Amount transferred from Income and Expenditure Account ..	8 19 7	544 16 3	Post Office Savings Bank ..	94 16 3	544 16 3
		£544 16 3			£544 16 3

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SOUTH AFRICA MEDAL FUND.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY, 1947.

	£ s. d.		£ s. d.
To Expenses	8 0 0	By Interest Received	51 7 3
,, Balance, transferred to Accumulated Funds	43 7 3		
	£51 7 3		£51 7 3

BALANCE SHEET AT 31st MAY. 1947

	£ s. d.	£ s. d.		£ s. d.
Accumulated Funds:			Investment in Hands of Trustees:	
Balance at 31st May, 1946 ..	1,712 11 2		Fixed Deposit, South African Permanent Mutual Building and Investment Society	1,755 18 5
Add Amount transferred from Income and Expenditure Account ..	43 7 3	1,755 18 5		
		£1,755 18 5		£1,755 18 5

Report of the Honorary Librarian for the Year ended May 31st, 1947.

Verslag van die Ere-Bibliotekaris vir die Jaar Geëindig 31 Mei 1947.

The Association's Library is housed in the Library of the University of the Witwatersrand, Johannesburg. The collection includes about 4,200 volumes, and 223 different titles are received currently.

Die Genootskap se Biblioteek word in die Biblioteek van die Universiteit van die Witwatersrand, Johannesburg, gehuisves. Die versameling bevat omtrent 4,200 bande en 223 verskillende titels word lopend ontvang.

Exchange of Publications.—During the year the following new names have been added to the free mailing list :—

Ruiling van Publikasies.—Gedurende die afgelope jaar is die volgende nuwe name by die vrye poslys bygevoeg :—

Association des ingenieurs electriciens, Liége.
Council for Scientific and Industrial Research, Pretoria.
Escola Livre de sociologia e' politica, Brazil.
Finnish Academy of arts and sciences, Helsinki.
Kamerlingh Onnes Laboratorium, Leiden.
The Library of Congress, Washington.
Scientific Liaison Office, London.
South African Scientific Mission, Washington.

The following societies and institutions have resumed the exchange relations which were interrupted by the war, and their publications are again being received currently.

Die volgende verenigings en institute het weer die ruiling van hul publikasies wat nie gedurende die oorlog kon gestuur word nie hervat, en dié word nou lopend ontvang.

Belgium :

Musée royal d'histoire naturelle (*Bulletin* ; *Memoires* ; *Memoires Hors série*).

Cameroons :

Société d'études Camerounaises (*Bulletin*).

Holland :

K. Nederlandsche Akademie van wetenschappen (*Archives néerlandaises de phonetique experimentale* ; *Archives néerlandaises de physiologie* ; *Archives néerlandaises de zoologie* ; *Proceedings* ; *Verhandelingen*).

Italy :

Accademia nazionale dei Lincei (*Annuario* ; *Memorie* ; *Rendiconti*).

Norway :

Kgl. norske vindenskabers selskab (*Arsberetning* ; *Forhanlingr* ; *Skrifter* ; *Oldsaksamlingens tilvekst*).

Poland :

Polish museum of zoology (*Annales* ; *Fragmenta faunistica* ; *Acta ornithologica*).

Donations from the following are gratefully acknowledged :—

Geskenke :—van die volgende word dankbaar erken :—

British Museum (Natural history) :

Exell, A. W. *Catalogue of the vascular plants of S. Tomé.*
Finnegan, S. *Ascari as agents transmitting typhus.*
Hinton, H. E. *A monograph of the beetles* Vol. I.

The Hon. Mr. Justice F. E. T. Krause:
Critical examination of the evidence relating to the discovery of the Main Reef Series on the Witwatersrand.

Professor H. H. Paine:
South African Journal of Science 29-33, 1932-36.

†Dr. J. B. Robertson:
South African Journal of Science 42, 1945.

New Titles Received:—
Nuwe Titels Ontvang:—

Academia scientarum Fennica.
Annales A. I-V. 1946.†

Biologie van de Zuiderzee tijdens haar drooglegging. 5, 1941†

Florida academy of sciences.
Proceedings. 1, 1936†

Hawaiian academy of sciences.
Proceedings. 16, 1940†

Naturforschende Gesellschaft in Zürich.
Neujahrsblatt. 146, 1944†

Nieuw archief voor wiskunde. 20, 1940†

Western Australia. Dept. of mines.
Report of the Government Geologist. 1940†
Report of the Mineralogist, Analyst & Chemist. 1941†

Wiskundige opgaven met die oplossingen. 17, 1939†

For a Catalogue of serial publications in this Library, and Supplement, see this *Journal*, vol. 30, p. xxv-xxix, and vol. 34, p. xxxiv-xxxvii. Subsequent accessions are listed in the Annual Report. Holdings appear also in the *Catalogue of Union Periodicals* and forthcoming Supplement.

Vir 'n Katalogus van periodieke publikasies in die Biblioteek, en Supplement, sien hierdie *Journal*, Band 30, p. xxv-xxix, en Band 34, b.xxxiv-xxxvii. 'n Lys van latere aanwinste word in die Jaarlikse Verslag gegee, en 'n volledige lys verskyn ook in die *Catalogue of Union Periodicals* en daaropvolgende byvoegsel.

P. FREER,
Hon. Librarian/Ere-Bibliotekaris.

University of the Witwatersrand/Universiteit van die Witwatersrand, Johannesburg,

5 Jun., 1947.

In Memoriam.

Alexander Logie du Toit, F.R.S., D.Sc., F.G.S.

Alexander du Toit was born on March 14th, 1878 at his parents' farm Klein Schuur and died at his home in Pinelands, Cape Town on the 25th February, 1948.

He was educated at the Diocesan College, Rondebosch, and graduated in the University of the Cape of Good Hope taking Honours at the B.A. in 1896 and subsequently obtaining the D.Sc. degree. He qualified in Mining Engineering at the Royal Technical College, Glasgow, in 1899, obtaining the Diploma therein. He studied geology at the Royal College of Science South Kensington in 1900-1. He held posts as lecturer in geology, mining and mine surveying in the Royal Technical College, Glasgow, and in geology at the University of Glasgow, 1901-2. On his return to South Africa in 1903, he became geologist to the Cape Geological Commission, 1903-1912; geologist to the Union Geological Survey, 1912-1920; and geologist to the Union Irrigation Department, 1920-1927.

In 1927 Dr. du Toit resigned from the government service and accepted a position as consulting geologist to the De Beers Consolidated Mines, a position which he occupied until his retirement in 1941.

Dr. du Toit was a Fellow of the Royal Society of London, a Fellow of the Royal Society of South Africa, Editor of that Society's Transactions and nominated as President, a Fellow of the Geological Society of London which awarded him the Wollaston fund in 1919 and the Murchison medal in 1934, President of the Geological Society of South Africa in 1917 and in 1927 and Draper Memorial Medallist in 1933, President of the South African Association for the Advancement of Science in 1934, and South Africa Medallist with grant in 1930, and also a president of the South African Archaeological and Geographical Societies.

Since his retirement in 1941 he received honorary degrees from the Universities of Cape Town, Witwatersrand, Pretoria and Natal University College.

During a period of 24 years, whilst in the employ of the government Dr. du Toit made detailed geological surveys of a very wide region, situated mostly within the Union, and wrote extensively on such territories not only from the regional but from the associated physiographical, stratigraphical or petrological aspects. His numerous maps, published by the Geological Survey, are a monument of accurate observation and grasp of detail and his discussions of a host of problems in South African geology show outstanding powers of correlation, synthesis and comprehensive review.

Dr. du Toit's work on the geological similarities of South America and South Africa, embodied in the book entitled *Our Wandering Continents*, provided a convincing argument for the existence of a continental drift and brought him fame abroad, whilst his standard text book on the geology of South Africa, the third edition of which he was preparing during his last illness, drew general attention to many unique geological features of Southern Africa.

To the great gifts and abilities which earned him the reputation among many of his colleagues of being the greatest scientist that South Africa has hitherto produced, Dr. du Toit added an indefatigable industry and an outstanding helpfulness to the many societies and individuals in his environment which brought him their lasting affection and admiration.

Dr. du Toit is survived by his widow and by one son to whom this Association extends deep sympathy.

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIV*,
pp. 1-14, March, 1948.

THE WORLD VIEW OF THE PHYSICIST

BY

H. H. PAINE,
University of the Witwatersrand, Johannesburg.

Presidential Address to the South African Association for the Advancement of Science, delivered 30th June, 1947.

Since the Association last met in annual session, it has lost by death a number of its members. Of these, I shall refer to two only. Sir Carruthers Beattie, a Foundation Member, was President in the year 1927-28. He was active in physical research in the earlier part of his life, but his great work was directing the University of Cape Town, of which he was Vice-Chancellor and Principal for twenty-one years. Professor Max Rindl was President of the Association in the year 1934-35. We remember him for the continuous effort he made for the better recognition of scientific research in this country.

It is twenty-two years since the South African Association for the Advancement of Science met in Oudtshoorn under the presidency of General Smuts. It is of interest to recall one of the topics that were discussed on that occasion. Not many months before the Association met, Professor Raymond Dart had announced the discovery at Taungs of a skull which seemed to be of very great importance in prehistory. Professor Dart, appropriately, was President of Section E that year and also the Evening Lecturer. Our records state that a cast of the skull was on view at one of the sectional meetings. The discovery had been announced overseas as well as in South Africa. The impression created abroad was that Professor Dart had over-emphasized the importance of his find. Overseas opinions have changed since then. At the Pan-African Congress on Prehistory held in Nairobi at the beginning of this year, Professor le Gros Clark of Oxford paid a tribute to Professor Dart's pioneer work. He stated that the significance of that work had not been over-estimated by its author, and that the first interpretation of these fossil remains was entirely correct in all essential details. Sir Arthur Keith has associated himself with Professor Clark's statement. It is a pleasure, on the occasion of the Association's return to Oudtshoorn, to record this recent tribute to the work which caused so much interest on the former occasion.

Oudtshoorn celebrates the centenary of its foundation this year. We appreciate the special honour that you, Mr. Mayor, and your Council have conferred on us by inviting us to visit you during a year which means so much to the citizens of this town. Though your celebrations do not take place till November, we should like to greet you all on the glad occasion and rejoice with you for the

pioneers of 1847. We should like to join with you in praise of the enthusiasm and faith which they expressed in founding a new township which serves not only as a centre for the business activities of the neighbourhood, but as a place where local memorials of the past may safely be enshrined and preserved for future generations.

As a topic on which to address you, it might have been suitable in this centenary year for me, as a physicist, to pass in review a century of progress in physics. There would have been an interesting event to serve as a starting point. At the 1847 meeting of the British Association for the Advancement of Science, a young, unknown amateur gave an account of some experiments he had been making on the heat produced when mechanical work was expended in friction. The paper would have passed unnoticed, as previous papers of his had done, but for the attention of another young man who had recently been appointed to the chair of physics at a Scottish university. The latter, by his striking observations, created a lively interest in the new work. The reader of the paper was James Prescott Joule and the interested listener Professor William Thomson, later to be known as Lord Kelvin. This was the first occasion on which serious attention was directed by the leaders of physical science to the convertibility of heat and mechanical power into one another.

It has seemed to me that the review of a hundred years' progress in physics, if it is to be worth while, could hardly be compressed into an hour's address; at least, I was not drawn to make the attempt. Yet my interests have prompted me to choose a no less ambitious topic—the world-view of the physicist. Perhaps it is a lifetime's experience of teaching physics that has led me to ask the question what science really means to a physicist, however inadequate may be my attempt at an answer.

The World View of the Physicist.

I.

The urgency of the war was a powerful stimulus to all kinds of invention. Victory often depended on finding some means of countering a powerful weapon in the hands of the other side or on devising some method of attack which would surprise the enemy and would enable us to press home the advantage before he had time to recover.

Most of these inventions and devices are of permanent value to the world and have made us still more conscious of the importance of science in its application to human welfare. So spectacular have been these triumphs over nature that many people have come to regard science as primarily a means of controlling nature and using its forces and powers in the service of man.

But we should not forget that man's unceasing quest for knowledge of the universe in which he lives is prompted in many cases by the simple joy of discovery and the sheer delight of learning nature's ways. His restless curiosity is not completely reducible to a mere search for food and physical comfort, though it may have originated in that way.

The different sciences and, in fact, all outward-reaching activities of the mind present us with different panoramas of the universe. There are many standpoints from which we may view the world around us. As physicists, biologists, philosophers, poets, we select the one that is most useful for our purpose. Each panorama has its value, and the value of one does not exclude the value of the others. It is to some aspects of the panorama of physics that I wish to call your attention this evening.

II.

Röntgen's discovery of X-rays in 1895 ushered in a new era in physics. It gave an immense impetus to physical research, and it was not long before other and still more sensational discoveries were made. The present year, 1947, marks the jubilee of one of the most important of these. In April, 1897, J. J. Thomson announced that in the electric discharge through a gas at very low pressure there are particles which have a very much smaller mass than that of the smallest atom recognized by the chemist. Each of these particles carries a charge of negative electricity. In fact, as was afterwards realized, they consist entirely of negative electricity. They are now generally known as electrons. The jubilee of the electron is being celebrated in London by the Physical Society and the Institute of Physics in September next, and it is intended to have a corresponding celebration in Johannesburg at the same time.

J. J. Thomson's work of fifty years ago may rightly be regarded as the experimental foundation of modern physics. It was of a quantitative nature and thus provided sure data for further advance. It was the gateway to a wide field of new phenomena in electricity and ultrachemistry. It was our first glimpse of the inside of the atom, the first to be discovered of the series of sub-atomic particles which have played such an important part in the development of modern physics. We have come to recognize quite a number of these particles. In the physical research of the last forty years, more attention has been paid to them and to the way in which they enter into the structure of the atom than to any other topic.

Shortly after the discovery of the electron, two new ideas were born which have had a profound effect on the world-view of physics. In 1901 Planck published his first paper on the quantum theory, and in 1905 Einstein announced his theory of relativity. The quantum theory soon proved to be the answer to several riddles that were puzzling physicists, and it has now become the theoretical basis of our knowledge of conditions in the atom.

The modern developments of these theories are essentially mathematical in character, and the ordinary physicist finds it difficult, not only to learn a new mathematics, but to take up the point of view that is implied. In part this is due to the inadaptability of minds which, having grown up in a certain way of thinking, find a reorientation difficult if not impossible. The late Lord Rayleigh, the last of the great physicists of the nineteenth century, when discussing an early paper of Niels Bohr on atomic structure, in which quantum principles were applied to the atom for the first time, remarked : "I saw it was of no use to me. I do not say that discoveries may not be made in that sort of way. I think very likely they may be. But it does not suit me." The particular paper Rayleigh had in mind hardly disturbs us now; but his confession might well express the feeling of many a physicist when confronted with some of the modern developments in physical thought.

In so far as this arises from the natural hesitation with which we accept new ideas and cast off old ones, it is not important. But I think it is something more than that. There are certain desirable elements in our physical outlook that are being lost sight of, and it is to some of these that I want to call attention. What I have to say may be regarded as an attempt to make out a case for the practical physicist who cannot follow wholeheartedly the present trends in mathematical physics, nor draw from the mathematics the sense of satisfaction the older physical theories provided, but who yet maintains his faith in the progress of physics and still desires to play a part in that progress. What are his standards and principles? What should be his attitude towards the mathematician? Mathematicians may be the pioneers of progress, and what they think to-day the physicists may think to-morrow; but progress in physics calls for the planning of a road along which the main army of physicists can travel. What are the qualities we look for in that plan?

Our analysis can best be undertaken by starting at the very beginning and enquiring how the physicist obtains his knowledge and what constitutes the panorama he is forming in his mind. The enquiry concerns not merely the trained physicist, but all those who try to think in an orderly way about the physical universe.

III.

Man's mind is, quite literally, imprisoned in his body. He has contacts with what is outside him through his five senses, and from the impressions he receives through these senses he tries to form some sort of picture of what the outside world is like. This process is going on, often unconsciously, all through our waking life. It has been going on throughout the development of the race.

Our sense impressions must be quite unlike the world from which they come. For example, the impression of warmth is nothing like the kinetic energy of the molecules of a hot body, which, physics

tells us, is the external cause of that impression. The sensation of sight gives us no idea of the physical nature of the light which produces it, and the contrast in colour between different lights is nothing like the contrast discovered by physics. Besides, our senses are notoriously unreliable and we must not stress unduly the evidence with which they provide us.

Repetition of these impressions makes them familiar, so that they are recognized when they return. It is the orderliness in these repetitions, confirmed by reports from others, which makes us conclude, and gives us justification in concluding, that there is an outside world which reacts on our senses and is the prime origin or external cause of our sensations and subsequent impressions. The reacting mind forms *notions* or *concepts* which in simple cases stand for elements in that external world and represent them in the mind. For example, our sense of sight is excited and we say that *light* is falling on our eyes.

Physics makes use of the impressions which come through three of our senses—sight, hearing and touch. Just as sensitiveness to physical contact is more prominent in lower forms of animal life and was evolved earlier than sensitiveness to light and sound, so in the case of the individual human being impressions through the sense of touch are the ones of which the new-born babe first takes notice. He must be forming the simple notions of a *pull* and a *push* quite early in life because the exertions of the muscles of arms and legs are amongst the earliest activities of which he becomes conscious; the resistance to these exertions which he experiences through his sense of touch makes him feel what a pull or a push is like. That grip of the hand must soon lead to the notion of *substance*, something of which he takes hold. Later, aided no doubt by sight, the notion of substance becomes more definite, developing into the further notion of a *piece* of substance, the origin of the concept of *particle* in physics. Notions of *here* and *there* and of *distance* probably arise as much from the sense of touch as from the sense of sight; a desired object is within reach or out of reach. Later on come the notions of *time* and of *movement*.

I have called attention to these particular notions or concepts because they are amongst the first to be formed in the mind and are amongst those most frequently used by the mind. They must therefore be regarded as amongst the most familiar concepts we have, so familiar that ordinarily we never feel the need of simplifying them. It is of very great significance in the development of science that these particular concepts, made more definite and precise of course, have become the postulates of the science of mechanics.

As impressions increase, notions or concepts increase and accumulate in the mind, pigeon-holed, as it were, in the memory. This accumulation of concepts may be regarded as the first stage in the mind's development. The next stage is reached when the mind starts to *relate* these impressions one to another. We associate warmth with the light from the sun. A sound or noise is heard when

one thing strikes another. A push moves this piece of substance from here to there. After the lightning comes the thunder. In this way the mind passes over from being a mere passive receiver of impressions to becoming a more active *observer* of the outside world from which the impressions come. It takes an interest in observing the various relations between the constituents of that world, though it may be more correct to say that these relations exist between the concepts in the mind.

Science begins when the growing mind recognizes a certain orderliness in these relations. The larger the stone, the heavier it is. The further away the lightning, the longer is the interval of time between flash and thunder-clap. An important climax is reached when, after a good deal of observation, it is found that the relations can be expressed quantitatively. The heaviness or weight of a stone is proportional to its size or volume, so that when you double the size you double the weight. Compare this simple statement with some of the well-known laws of physics ; for example, Boyle's law, that, when the temperature remains constant, the pressure of a gas is inversely proportional to its volume; Ohm's law, that the electric current through a given circuit is proportional to the electromotive force driving it; Newton's law of gravitation, that the attraction between two particles of matter is inversely proportional to the square of the distance between them. The laws of physics are these quantitative expressions of the relations between the objects which are represented in our minds by certain concepts. Note the mathematical form of these statements or laws. The physicist obtains most satisfaction if he can represent his results by means of an equation, even an empirical one.

This brings us to a very important point. While the concepts we form in our minds may be very distorted representations of the outside world, we are on much surer ground when we are dealing with the relations between them. For example, suppose we have two sources of light; our knowledge of the nature of light is certainly very inadequate; but we can make photometric measurements and as a result conclude, say, that one source is twice as bright as the other. This statement has none of the vagueness associated with our ignorance of the nature of light.

IV.

The study of such relations, then, is the main object of physics. Ever fresh discoveries of them mark the advance of science. They are definite achievements, independent of our ignorance of the absolute nature of the outside world. But the average physicist asks for something more from science—another set of relations, but of a different kind. As discoveries are made, he seeks to relate the new phenomena to the better known and more familiar images in his mind. We sometimes call it the explanation or interpretation of phenomena. We explain a phenomenon when we are able to

describe it satisfactorily in familiar terms or concepts, so that it ceases to be new and strange and becomes *something which our previous experience would lead us to expect.* This is equivalent to answering the question *why* the phenomenon or event occurs.

Consider the following as an illustration. The flight of an aeroplane is a common sight nowadays, but perhaps we can remember the time when we were excited by the fact that aeroplanes could stay off the ground, and when we wondered why they did not fall as other heavy bodies do. We may have seen aeroplanes of historical interest in museums; often they hang suspended from the ceiling by cords. These particular machines do not fall to the ground, but we are not surprised; we see the cords holding them up. The phenomenon of suspension is so familiar that we hardly give the situation a thought. In a similar way, if we saw an aeroplane in the sky suspended by cords that were being held by a troop of angels, say, we might be puzzled by what the angels were doing but not by the behaviour of the aeroplane; the latter would be just another example of a body suspended above the ground by cords, like the aeroplane in the museum. Come now to the actual facts. We learn by observation that the tilt of the aeroplane wing is adjusted so that as the wing moves forward it keeps forcing the air downwards, and thereby brings about by reaction an upward force on the wing; just as the aeroplane's propeller, by forcing air backwards, brings about a forward force on the aeroplane. With an elementary knowledge of mechanics, we recognize in that upward force the equivalent of the tension in the stretched cords holding up the museum aeroplane. This recognition removes the strangeness; we can now describe the phenomenon of the aeroplane in the sky in terms of notions or ideas with which we feel quite familiar. We have explained the phenomenon.

Let me give you another illustration which is not as simple as the previous one, but is thereby, perhaps, sufficiently strange and remarkable to make you desire the removal of some, at least, of the strangeness. (Keep in mind, of course, that it is the *process* of the removal which I am wishing to stress.) We have been learning recently of the enormous quantity of energy that is locked up in the atom—enormous, that is to say, when thought of in relation to the smallness of the space in which it is contained, so that a few pounds of uranium may release as much energy as many thousands of tons of ordinary high explosive. The energy is actually in the atomic nucleus which occupies an incredibly small fraction of the volume of the atom. We cannot help being puzzled that so much energy is concentrated in so small a space, and our minds press for an explanation. We can give a simple explanation with the help of elementary principles. Here again the explanation is essentially mechanical, involving the repulsion that exists between "like" electric charges.

The nucleus of an atom is made up, in part, of protons which are tiny particles each carrying a charge of positive electricity.

These positive charges repel one another, and, generally speaking, the closer they are brought together the greater the force of repulsion. For light atoms such as hydrogen, helium and lithium, the number of protons in the nucleus is small, but for the atom of uranium the number is 92. In the splitting of the uranium atom, the nucleus divides into two roughly equal parts, each part being strongly charged since it contains something like 40 to 50 protons. Why this division should occur is a much more serious problem which is still unsolved. But assuming it has taken place, it is not hard to realize that the repulsion between the two large positive charges, initially very close together, may be very great, so that they are hurled apart with great violence, all the greater because the two parts were initially so close together. Conversely, the compression of a number of electric charges into a very small space necessarily involves the performance of a large amount of work which goes to form the potential energy of the compressed system. The splitting of the nucleus is the release of some of this energy.

V.

I have spoken of these descriptions as explanations of the two phenomena. We might have called them theories or hypotheses. But I should like to speak of them now as *pictures in the mind*, like cinematograph pictures, which we create to represent what is happening in nature. We try and picture in our minds how the aeroplane remains poised above the ground. Our eyes do not see the forces acting on it in the way we described; our imagination puts them into the picture, and if we are mechanically minded, our minds see them there just as clearly as our eyes see the cords holding up the aeroplane in the museum.

There are certain desirable qualities which should characterize these pictures. They should be simple and clear, and this not merely for some aesthetic reason. The mind does not construct them solely to explain what it has been observing, and to gain the consequent satisfaction of an achievement. The picture usually introduces us to a new problem, prompting us to ask a new question. If the picture is simple and clear, the answer, probably, is not far to seek. And so the mind is led on, step by step, from one piece of knowledge to another. It moves the more readily, the simpler and more familiar the concepts used in constructing the picture. It is this familiarity which makes the picture clear.

Let me illustrate this by discussing one of the best-known discoveries in the history of science, the discovery of universal gravitation by Newton. The main idea came to him when, as a young man who had just taken his degree at Cambridge, he was staying at his mother's farm in Lincolnshire, England. Part of the story is well known, how that he happened to see an apple fall to the ground and, being in a meditative mood, asked himself why it did so. The question was not new, but Newton gave a new answer. He suggested

that the earth was pulling it. We can make objects approach us by pulling them towards us; the earth was doing the same sort of thing, as though it were stretching out a long arm and drawing everything to itself. Newton did not *observe* this pull, he *inferred* it, because falling bodies behaved exactly as though the earth were pulling them. (We might say that this was an hypothesis he put forward to explain the fall, but we will go on referring to it as a picture he formed in his mind.) This picture was simple and clear, and his imagination started to play with the possibilities that were suggested. Objects fall to the ground whether they are close to the ground or on the tops of high buildings or mountains; so that the power to attract things in this way is not confined to the immediate neighbourhood of the earth's surface. How far away does it extend? Does it extend to the moon? Is the earth pulling the moon in exactly the same way that it is pulling the apple from the tree? Is that the reason why the moon circles round the earth, just as a stone whirled about in a sling circles round the hand because of the inward pull we thereby exert on the stone? We might expect the pull of the earth to become weaker the further away we go, and certain astronomical observations led Newton to the inverse square law as relating the strength of the pull to the distance from the earth's centre. A simple calculation he was able to make, one of the most famous calculations in the history of physics, showed that the supposition fitted the facts of observation exactly, and accounted completely for the rotation of the moon round the earth, in particular the time the moon took to describe the orbit. Note again, that Newton could not observe the earth pulling the moon, he inferred it, because the moon behaved exactly as though the earth were pulling it. We might expect the pull of of the earth to become weaker the further away we go, and certain astronomical observations led Newton to the inverse square law as relating the strength of the pull to the distance from the earth's centre.

The picture enabled Newton to proceed further still. If the earth were pulling the moon, the moon also must be pulling the earth, for all such actions are reciprocal. The moon must be pulling everything on the earth, the water of the oceans, for example. This thought soon led him to account in that way for the tides observed in the oceans of the world. He went still further afield. He saw that the same kind of force, gravity, accounted for the movements of the planets round the sun. The law of gravitational attraction became a universal law, applicable to any two bodies anywhere in the universe.

The great speed of discovery during the last half century, especially in the realm of atomic physics, is to be attributed in large measure to the vividness with which the movements of molecules and particles like them can be visualized in the mind, like the movements of billiard balls. We expect the laws of motion to apply to the molecules in space as they do to billiard balls on a table, except that the former movements are in three dimensions and the latter in two. We expect each molecule to move in a straight

line until it collides with another molecule or with the wall bounding the space in which it is confined. We can watch the movements of billiard balls, and they become so familiar that we easily picture them in our minds even when we are not watching them. What we have seen with our eyes can help us with what we want to see with our imagination. In this case the mental picture is very clear, so clear that we can anticipate how the molecules or atoms will behave in given circumstances. As a result, experimental technique has almost kept pace with the imagination, enabling us in some instances to observe directly the behaviour of individual atomic particles. This quality of vividness in our mental pictures should be ascribed to the *familiarity* of the concepts which we use in constructing these pictures. The mind works easily with familiar things, with *particles* in *motion* under the action of *forces*. It was Newton who started physics on this particular road of discovery, where mental pictures are constructed from these familiar mechanical concepts.

Our pictures, of course, must be as correct as possible. They must not include anything which our observation tells us should not be there. But they must be able to include all that our observation tells us should be there. Discoveries, when made, must be fitted into the picture. Very often the design of the picture so far constructed suggests to us the presence of something we have not yet observed ; the great discoverers are the people who have the happy gift of detecting these hidden clues, which are then confirmed by experiment and observation. Sometimes observations are made which necessitate drastic alterations in the design.

VI.

If we look back over the past, we find that while the main structure of physics, as expressed in the laws of physics, has risen steadily—that is to say, while knowledge has increased—the pictures and theories which physicists have created have undergone radical changes. As examples, we may consider the changes which have occurred in ideas relating to the motions of the planets, the transmission of light through space and the nature of the atom.

Descartes, at the beginning of the seventeenth century, was the first to put forward a physical theory which aimed at explaining why the planets moved in circles round the sun. He pictured all space as filled with some sort of fluid medium. The sun, a large rotating body, set the surrounding medium in rotation—vortex motion as it is called—something like the rotation we produce when we stir a cup of tea. The planets were carried round the sun, as tea-leaves or other floating matter are carried round in the teacup. This picture is certainly clear and is easily formed in the mind ; that probably accounts for the fact that many astronomers accepted it long after Newton had shown that it was contradicted by observation. Newton, as we have seen, introduced the idea of gravitation, and the inverse square law made the idea applicable to

all parts of the universe. For the last two hundred and fifty years, the theory of gravitation has proved almost completely satisfactory. Slight discrepancies have been noticed from time to time. Some of these actually pointed to the existence of a new planet which was afterwards discovered—a remarkable confirmation of the theory. Others, however, were left unaccounted for until Einstein introduced an entirely new approach to the whole problem. The relativity theory of gravitation has been successful in accounting for all the observations. But the new approach is not pictorial in the way gravitational attraction seemed to be; there seems to be little likelihood of our making a picture of the new outlook. According to the new theory, planetary motion is the consequence of a property of space, not the space we ordinarily think of, but the mathematical "space-time" of relativity theory. According to this theory, we can no longer rightly think of the sun pulling its planets, or even of the earth pulling the apple from the tree.

Light passing through space has, at various times, been pictured either as a stream of particles or as a train of waves. During the eighteenth century the particle theory was in favour, but from about the beginning of the nineteenth century the wave theory has been accepted universally. It was difficult, however, to picture waves otherwise than in a medium, for that is how we usually recognize them—like ripples on water or sound waves in air. Hence, an aether was postulated to carry the waves. All attempts to gain direct evidence of the existence of this aether failed. Also, if the waves were of a mechanical nature, as sound waves are, the particular mechanical properties which the aether would have to possess in order to explain the very great velocity of light seemed to be incompatible with one another. Nowadays, light is still regarded as a wave phenomenon, but the waves have become more mathematical and less mechanical; the aether has dropped out of physics.

As regards the atom, the nineteenth century pictured it as a hard, indivisible particle, with certain characteristic chemical properties. J. J. Thomson's experiments, however, led us to believe that the atom could be divided into parts, and the last fifty years have seen a great development in our knowledge of its structure. Thirty-five years ago, Rutherford suggested that the atom was like a miniature solar system. Negative electrons circled round a positive nucleus as the planets circled round the sun; an electrical attraction between nucleus and electrons replaced the gravitational attraction between sun and planets. This picture probably gives us a very fair, general idea of the atom as far as its structure is concerned. But regarding it as a working model, which behaves in accordance with the ordinary laws of mechanics, it fails to account for the most familiar atomic phenomenon we observe in physics, the emission of light of precise wavelengths as revealed in the optical spectra of the various elements. Bohr modified the application of ordinary mechanics by introducing certain principles of the quantum theory. He made a calculation which, in its

importance and its power to convince, reminds one of Newton's calculation on the extension of gravity to the moon. For he showed that, assuming these quantum principles, the positions of the hydrogen spectrum lines could be calculated theoretically with a precision as great as that reached in the experimental measurement of them. But the model itself, the comparison with the solar system, became less and less useful as the quantum mechanics developed until now it is almost ignored in spectrum research. Part of this uselessness may be attributed to the fact that in the atom the electrons seem to have lost nearly all their particle nature. They can no longer be treated as points travelling in planetary orbits, but seem, somehow, to be spread over the space surrounding the nucleus, and to behave like waves encircling the nucleus. Though we must not take the analogy too seriously, the situation reminds one of what happened to the innermost moon of Saturn. Astronomers surmise that the orbit of this moon became gradually smaller until the tidal action on its surface became so violent that the moon disintegrated, spreading out into the ring or rings we now see.

It should be pointed out that the quantum theory, while providing us with the rules for the changes in the atom which give rise to the spectrum lines, offers us no hint of the reason why these changes should occur. It does not pretend to provide explanations of what goes on in the atom, in the way that the Newtonian mechanics, with the law of gravitation, gives us explanations of the changes we observe in the solar system.

I have selected these examples in order to indicate the kind of change which is occurring in modern physical thought as we approach the study of ultimate, fundamental quantities like space and the atom. The tendency is away from our ingrained habit of picturing the external world in terms of matter, motion and force. The pattern to which we have grown accustomed seems in many cases to have become inadequate; perhaps it is not fine enough to represent the fine structure of the universe, or vast enough to aid us in exploring the depths of space. Seeing that our sense impressions are the origins of the concepts with which our pictures are constructed, perhaps we ought not to be surprised that these pictures should fail to represent what is beyond the reach of our senses.

It has been suggested that physics is reaching a stage when such things as models, pictures and physical hypotheses will be abandoned altogether; the desire for them seems to reveal a mental immaturity, and perhaps we shall grow out of it. Dirac, one of the leading mathematical physicists of the present day, has put this point of view very clearly. He writes: "The main object of physical science is not the provision of pictures, but is the formulation of laws governing phenomena and the application of these laws to the discovery of new phenomena. If a picture exists, so much the better; but whether a picture exists or not is a matter

of only secondary importance. In the case of atomic phenomena no mental picture can be expected to exist in the usual sense of the word 'picture', by which is meant a model functioning essentially on classical lines."

VII.

I think we are now in a position to state more clearly the main issue of our enquiry and to attempt an answer. Generally, what constitutes the world-view of physics and what does physics aim at doing? More specifically, what should be the attitude of the physicist, to-day, towards the practice of constructing pictures and framing hypotheses? Will all pictures based on the concepts derived from our sense impressions pass out of use?

As we have seen, the mind generally does two things with the observations that it makes: (1) It discovers the laws which express the relations between the phenomena it observes and the laws according to which events occur. (2) It constructs mental pictures to explain or interpret these laws and the phenomena to which they refer by associating new phenomena with simpler and more familiar ones.

Then again, in the development of science, the laws of physics accumulate and are not destroyed. They may be modified or extended, but substantially they remain as permanent contributions to our knowledge of the outside world. But, as we have seen, our mental pictures continually change; they are often abandoned entirely and replaced by new ones. Their value, therefore, appears to be shortlived; in that sense they are of secondary importance.

Hence, we are probably right in concluding that the chief aim of physics is the discovery of the laws of physics, the relations between phenomena and events expressed in a mathematical form. The construction and use of mental pictures is a valuable means of achieving that aim. These pictures must be judged by the extent to which they prompt new enquiries leading to fresh discoveries. The world-view of physics contains both elements, laws and pictures.

"To the physicist, a theory is a policy, not a creed." So J. J. Thomson taught in his lectures and books. We do not ask whether a theory or an hypothesis be true or not. We do not regard our pictures as photographs. They are representations of the outside world designed to make that world more familiar, so that our imaginations can play about in it more freely. They help us to collect our thoughts and express them, and provide us with jumping-off points for future thinking. They enable us to make intelligent anticipations of phenomena which have not yet been observed, but which seem to be on the point of coming within our field of observation. If this mental activity be brought about, it is good policy to construct them, however crude they may be and however soon we may have to change them.

There are very few discarded theories which have not some achievement to their credit. It was the solar system model which enabled Bohr to apply quantum principles to the atom for the first time and to make the calculation which was such an impressive confirmation of the soundness of his new theory.

When, as in the cases we considered just now, a picture is found to be inadequate, but, as yet, no other has been created to take its place, it may be useful to retain the old one for certain limited purposes. It may still be a useful analogy which co-ordinates observations in our mind and helps us to think. Perhaps the earth does not pull the moon in a crudely mechanical sense; but it *seems* to do so, and this analogy, expressed in the Newtonian law of gravitation, is far more useful in handling the vast majority of gravitational phenomena than relativity theory is likely to be for a very long time. Granted we have no grounds for supposing the existence of a light-carrying aether, it is often useful to *pretend* that it exists, if only to help our imaginations to picture light waves and the way in which they behave. Finally, we can still say that the atom, with its nucleus and electrons, reminds us of the solar system in certain respects, and the analogy is useful, if only for purposes of exposition.

The mathematical formulation of a law of physics seems to be the culmination or climax of an enquiry into a particular group of phenomena. It seems, therefore, to stand for the perfection of knowledge. Eddington has remarked that " mathematical formulation enables us to state a conclusion which does not go beyond the ascertained facts". That is why the laws of physics mark the advance of physics and form such a sure foundation for science. Our pictures and theories go beyond the ascertained facts, and that is why they are so useful. They suggest facts not yet ascertained and prompt us to search for them by observation and experiment. It is conceivable that mankind may ultimately achieve a consummation of physical knowledge which is mathematical, but the undreamed-of discoveries of the last fifty years would suggest that we are still far from such finality.

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A CENTURY OF ASTROPHYSICS.

BY

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Presidential Address to Section "A" of the South African Association for the Advancement of Science.

Read 30*th June*, 1947.

Astronomy, the most ancient of the natural sciences, has a long and glorious history. I know of no other science which can boast of a discovery comparable to that of the Saros cycle more than 2,500 years ago. This cycle consists of 6,585 days and is the period which separates successive members in any series of lunar or solar eclipses. We do not know the name of the person who made this great discovery, nor the approximate date when it was made. It seems to have been known to Thales in 585 B.C. It is practically certain that the discovery was made in connection with lunar eclipses, but if we take into account the difficulties which existed in those early times in connection with the recording of phenomena, the discovery appears a truly remarkable one even in the modern scientific sense.

I should like to quote two further proofs of my contention that ancient astronomy was a science in the modern sense, namely the star catalogue of Hipparchus and the Ptolemaic theory of planetary motion which was based on it. Hipparchus realised the importance of accurate observations of the positions of the stars and the planets, and the theory of epicyclic motion which forms the basis of the Ptolemaic theory is said to have originated with him. Although it was based on the fallacious idea of a geocentric universe, this latter theory was an earnest attempt to account for the motions of the heavenly bodies.

During the 16th century Copernicus showed that the premise of the Ptolemaic theory was wrong, and the development which the science of astronomy underwent as a result of the observations of Tycho, the conclusions which Kepler drew from them, and especially the work of the incomparable Newton, made it a model for the whole of physical science. Incidentally, the model has never been equalled.

Celestial dynamics, that vigorous offshoot of astronomy, which started with Newton, put the rest of the science in eclipse for more than a century, and gave us the wonderful discoveries of Newton himself, Halley and Laplace, amongst others. Those were the days when theory caught up with observation, a state of affairs which is very far from true in astrophysics to-day. Sir

William Herschel towards the end of the 18th century led the current of astronomical endeavour back to the study of astronomy proper, by showing that the telescope was still capable of making wonderful discoveries. He has had many followers especially in America in our own times. I mention the names of the two most important ones, Hubble of Mount Wilson and Shapley of Harvard. The efforts of these people, with the help of the large American telescopes, have pushed our frontiers in space back to hundreds of millions of light years.

But I wish to speak to you about yet another offspring of astronomy, a vigorous youth of about a hundred years, astrophysics. Like his elder brother, celestial dynamics, he has at times very nearly succeeded in crowding the parent science, astronomy, off the stage. Since about 1860 one remarkable discovery after another has fallen to astrophysicists, and even the last few years have seen the solution of a very old problem, namely, the identification of the coronal lines.

The eminent philosopher, Comte, somewhat more than a 100 years ago, put astronomy at the head of the hierarchy of the physical sciences. Whether it was because of its long history or whether because of the fact that the science of astronomy busies itself with things celestial, I do not know. At any rate, Newton had already brought astronomy down to earth when he discovered that it is the same gravitation which makes the apple fall to the ground and which keeps the planets and their satellites in their respective courses. Astrophysics, even more so, was destined to take astronomy off its lofty pedestal by bringing the analysis of stellar atmospheres within the range of the physicists and chemists.

It was the same Comte who categorically declared in 1823 that one secret at least must for ever be hidden from mankind, and that is the chemical make-up of the celestial bodies. But even at that time the foundation had been laid for the science which was to prove Comte wrong. Around 1814 Fraunhofer, the brilliant optician of Munich, had discovered, after a careful analysis of the solar spectrum, that it was not absolutely continuous, as people thought who had investigated it before him, but that it was broken up by a series of dark lines of different degrees of blackness. Fraunhofer passed sunlight through an opening in his window shutter and then through a prism, just as Newton had done about 150 years earlier. The latter had used a round hole in the shutter and merely allowed the sunlight to fall on the wall after passing through the prism. Fraunhofer used a narrow slit opening, parallel to the axis of the prism, and examined the light which emerged from the prism through a theodolite. Through his inferior experimental arrangement Newton had missed a very important discovery and the birth of astrophysics was delayed for 150 years.

After he convinced himself that the dark lines in the solar spectrum were real, Fraunhofer made a detailed map of the spectrum of the sun as far as his apparatus allowed. He did not

live to discover or know their meaning. Fraunhofer's apparatus, briefly described above, is a spectroscope, and this instrument, together with its later development, the spectrograph, form the astrophysicist's most important tools to this day.

But astrophysics proper may be said to have begun with the experiments of Kirchoff and Bunsen in 1859 and the subsequent enunciation by Kirchoff of the laws which govern the formation of dark and bright lines in spectra. Many physicists before Kirchoff and Bunsen had puzzled over the ubiquity of the D lines of Fraunhofer. This fairly close pair of lines was observed in the spectra of almost anything. Some people noticed that they were particularly intense in the spectra of flames which contained a sodium compound, but because they also appeared in the spectra of flames where sodium was not known to be present, no one guessed that the D lines betrayed the presence of sodium. To-day we know that sodium occurs in most ordinary materials and that even a trace of sodium suffices to render the D lines visible in the spectrum of a flame.

Kirchoff and Bunsen made their fundamental discovery by first observing in their spectroscope the D lines as emitted by a gas flame containing some sodium compound. Then they passed weak sunlight through the flame and the slit and observed the D lines of the solar spectrum bright instead of dark, because they were rendered bright by the emission of the flame. This was according to expectation. But when they intensified the sunbeam passing through the flame and the slit, they found to their great astonishment that the D lines were no longer bright but very dark. The conclusion was obvious, the flame which by itself could give rise to the emission of the characteristic D lines also had the power to absorb light of the same wavelengths. Kirchoff continued his experiments and eventually formulated the three laws of spectroscopy which bear his name. They are (1) an incandescent, i.e. glowing, solid or liquid (or dense gas) radiates a continuous spectrum; (2) a rarefied gas when heated sufficiently emits a characteristic bright line or emission spectrum; (3) the spectrum of a gas placed in front of a hotter source of continuous radiation consists of dark absorption lines at just those wavelengths that it regularly emits.

The discovery of these laws opened a vast new territory to the astronomer. Most stellar spectra were known to be bright crossed at irregular intervals by dark lines. This meant that the radiating surfaces of the stars, like that of the sun, consisted of two parts, a hot dense underlying region giving a continuous spectrum, and a cooler but gaseous overlying region in which the absorption lines were produced. If these dark lines could be matched with those obtained in the laboratory from known elements the chemical constitution of the stellar atmosphere could be determined. Celestial objects giving bright line spectra at once proved them to consist of incandescent gases and their consti-

tution could likewise be determined. For the last 90 years astronomers have been busy identifying the thousands of spectral lines occurring in the spectra of the sun and other celestial objects, and there are to-day a relatively small number of lines whose origins have not been demonstrated. The difficulty in many cases has been to reproduce in the laboratory, conditions even distantly approaching those obtaining on the stars.

But astrophysics to-day is no longer a merely qualitative science. It has advanced considerably since the early days, when the mere observation of the spectrum of a heavenly body, which had not been observed before, enabled the observer to make important discoveries. Several instrumental advances aided in this progress. I mention only the most important ones. Firstly, there was the development and the perfection of the dry photographic plate which enabled astronomers to make permanent records of stellar spectra, and made the very cumbersome visual analysis of spectra unnecessary. The completion of large reflecting telescopes, especially in the U.S.A., also contributed to the advance of astrophysics, because these instruments are eminently suitable for the spectral investigation of faint objects. Most of the large modern telescopes have one or more spectrographs, each especially designed for them. A further instrumental development which has played an important part in the progress of Astrophysics was the discovery and the development of the different kinds of photometers, this enables astronomers to measure the intensities of the continuous and the line spectra of celestial objects.

On the theoretical side there have been very important developments which have helped the astrophysicist to interpret his observations properly. I mention in the first place the measurements of atomic spectra in the laboratory, and the very big advances in our knowledge of atomic structure made by theoretical physicists during the past 30 years. The most important discovery in the field of theoretical astrophysics was that of the ionisation formula first given by Saha in 1920. Soon after its discovery it appeared that modifications of the ionisation law could be applied to many situations arising in the stars, and these applications gave a very good insight into the physical conditions in the atmospheres and the insides of the stars. To quote one example, it at once gave a meaning to the series of spectral classes of the stars discovered previously by Pickering and his co-workers at Harvard.

In order to give you a better idea of the achievements of astrophysics during the past hundred years, the first century of its existence, I propose to deal with the subject under various headings. I shall try to answer briefly the following questions : What has astrophysics taught us about (1) the planets and comets; (2) the outside of the sun; (3) the corona; (4) the outsides of the fixed stars; (5) the gaseous nebulae; (6) physical conditions in interstellar space; (7) the insides of the stars.

(1) Planets and Comets.

The planets are cold bodies which shine by reflected sunlight and it is something of a surprise that the spectroscope is capable of revealing to us anything about the chemical constitution of their atmospheres. In the case of Mars the sunlight after passing through its atmosphere is reflected at the solid surface and passes through the atmosphere a second time before reaching us on the earth. The other planets with atmospheres, Venus, Jupiter, Saturn, Uranus and Neptune, are surrounded by permanent layers of clouds which reflect the sunlight before reaching their surfaces. These clouds appear to consist of solid particles of some kind floating in a gaseous medium. The sunlight passes to and fro through a very small depth of the atmosphere before coming to us. If one remembers that the original solar spectrum contains hundreds of dark absorption lines, to which our own atmosphere adds a number of molecular bands, one can understand that only very careful observations will reveal evidence of the presence of gases in the atmospheres of the planets.

Adams and Dunham were able to prove that the atmosphere of Venus contains a large proportion of carbon dioxide. They found that the sunlight reflected by the clouds on Venus passes through the equivalent of a column of carbon dioxide gas at atmospheric pressure somewhere between 1,200 feet and 2 miles long. Other investigators found that the amount of oxygen in the same layer must be less than that in a column one yard long at atmospheric pressure. The amount of water vapour must be less than that in our atmosphere by a factor of ten.

The spectroscope reveals no water vapour or free oxygen in the atmosphere of Mars. Adams and Dunham conclude that the atmosphere of Mars contains less than five per cent. of the amount of water vapour and less than one tenth of one per cent. of the oxygen in our atmosphere.

The spectra of the upper reaches of the atmospheres of the four major planets, Jupiter, Saturn, Uranus and Neptune reveal the presence of large quantities of methane (CH_4). Ammonia seems to be very abundant in the atmosphere of Jupiter, less so in that of Saturn, and absent in that of Uranus and Neptune. These differences are due to varying temperatures on the planets. The temperatures in the outer layers of the major planets are as follows: Jupiter −216° F., Saturn −243° F., Uranus −300° F. and Neptune −330° F., the last two being somewhat uncertain. Methane boils at −259° F. and freezes at about −300° F., hence one would expect all the methane on Jupiter and Saturn to be in the gaseous state, while some of it will be gaseous on Uranus and Neptune. Ammonia is far less volatile, it boils at −28° F. and freezes at −108° F. Even on Jupiter, the hottest of the four planets under consideration, much of the ammonia will be in the frozen state, and the gas which gives rise to the spectrum, must be sublimed from the crystals. On Saturn, which is colder,

there is less free ammonia gas, and on Uranus and Neptune not enough to give observable spectral lines. It is very probable that hydrogen gas is a very important constituent of the atmospheres of the major planets.

Wildt's recent theories of the structures of Venus and the major planets owe very much to the spectroscopic results mentioned above.

The spectroscope has also given us many clues to the understanding of the way in which comets shine. Comets are members of the solar system which move in very eccentric orbits as a rule, i.e. during part of the orbit they are far from the sun and for the rest approach it closely. They move much faster when close in and hence spend a relatively short time close to the sun. When a comet is far away from the sun it consists of a swarm of solid particles most of them probably quite small. These particles are porous and have a lot of gases absorbed in them. When far out very little sunlight falls on the comet, the particles remain cold and they reflect very little light, and the comet is invisible. As it approaches the sun the particles warm up and the absorbed gases begin to appear. These are immediately blown away by radiation pressure of the sun's rays and carry away with them small solid particles. When this stream becomes big enough the gases and the particles reflect enough light to make a coma and a tail visible, the latter continually growing as the comet becomes hotter.

But not all the light by which a comet shines is reflected sunlight; when the light is analysed through a spectroscope it turns out that much of it, especially when the comet is close to the sun, consists of bright lines, mostly molecular bands. The molecules involved are N_2, CN, CH and C_2, and recently the Yerkes observers have added OH and NH. Very close to the sun the comet spectrum shows lines due to metallic atoms, indicating that the comet particles become hot enough for these elements to begin to evaporate.

Wurm has investigated the stability of the various types of molecules involved in the light emission of the comets and finds that those of CO and N_2 break up less easily than those of C_2, CH and CN. The latter when freed soon break up in the head of a comet. The more stable molecules of CO and N_2 are blown away in the tail, supplying much of its visibility. Near the sun it becomes so hot in the head of the comet that even these molecules quickly break up, and as a consequence the head of the comet or coma quickly decreases in size. In this way the problem of the sudden shrinking of Halley's comet in 1910 from a diameter of 230,000 to 40,000 kilometers can be explained.

(2) THE OUTSIDE OF THE SUN.

Astrophysics began with the solar spectrum and the sun has always received considerable attention from the astrophysicists,

partly because it sends us so much light that its spectrum can be studied in minute detail, and partly because astronomers have always realised that a thorough understanding of solar radiation is necessary for the understanding of the radiation of the millions of stars which people space. The sun is the only star which gives an appreciable disc in our telescopes, and for this reason it is also the only star for which we can observe variations in the emission across the disc under ordinary circumstances. As evidence for the importance attached to the study of solar radiation one may mention the building of special long focus telescopes for the study of the solar spectrum. There are even whole observatories devoted solely to the study of the sun. Big sums of money and much time have been spent in the past for the observation of total eclipses of the sun, in order to glean, during the few minutes of totality, some additional information about the way in which the sun radiates its energy. The American astronomer Mitchell has travelled 100,000 miles in half a century for a total of 26 minutes of totality.

Up to the depth to which we can see into the sun's atmosphere there are only about two grams of matter over each square centimeter of surface. One gets some idea of the enormous size of our luminary when one calculates to how much the two grams add up over the whole of the sun's surface: one hundred thousand million million tons. This is one twenty thousand millionth part of the sun. In this small or enormous sample—depending upon the way one looks at it—more than 60 of the 94 elements have been identified by their spectral lines. The 30 odd elements whose spectral lines have not been found are chiefly those which have no important lines in the part of the spectrum which can be observed. Some of them happen to be elements which are very rare on the earth, and may be equally rare on the sun.

The American astronomer, Russell, demonstrated 20 years ago that apart from certain notable exceptions there is a close analogy between the chemical composition of the solar atmosphere and that of the earth. His pioneer investigation has recently been repeated by Menzel and others using more refined theories in connection with the atom. Russell's interesting conclusion was confirmed, and in addition a fairly reliable estimate has now been given of the abundance of hydrogen and helium in the solar atmosphere. Menzel finds that of all the atoms in the sun's atmosphere over 81 per cent. are hydrogen and over 18 per cent are helium atoms, leaving a fraction of one per cent. for all the other atoms put together. There are indications that the inert gas neon is also more abundant in the solar atmosphere than on the earth.

The question may well be asked whether the sun's atmosphere constitutes a fair sample of the whole body; is it not possible that the light gases hydrogen and helium have risen to the top as they would do for instance in our atmosphere? There is plenty of evidence of convection currents in the sun, e.g. the sunspots.

These would prevent stratification if it occurred on a large enough scale. From the observations it is not possible to state the exact extent of convection in the sun.

It is interesting to note that astrophysicists have for a long time suspected the sun to contain a very high proportion of hydrogen. Difficulties which cropped up in the theories of the internal structure of the sun as many as 20 years ago, could only be removed by the assumption of a very high hydrogen content. Furthermore, there is evidence that the sun is in no way exceptional in this respect.

There exists to-day a very satisfactory theory of the solar atmosphere, i.e. of that part of it known as the reversing layer, where the absorption lines of the spectrum are formed. The photosphere which emits the continuous spectrum radiates like a black body of about 6,000° K., and the gases in the reversing layer behave as one would expect them to do in thermodynamic equilibrium at a slightly lower temperature. Astrophysicists maintained some time ago that they knew more about the solar atmosphere than meteorologists knew about our atmosphere, and it was no empty boast. Now that balloons and V2 rockets are being sent up so high into our atmosphere, I doubt whether the claim still holds. It should be added that the upper reaches of the sun's atmosphere, the so-called chromosphere and especially the corona are very imperfectly understood.

The reversing layer is the lowest few hundred miles of the solar atmosphere. Above it the much more tenuous chromosphere stretches for 10,000 miles and more. In connection with the latter astrophysicists find it at present impossible to explain on any reasonable assumption how it remains supported and also to account for the occurrence of certain high excitation potential emission lines in its spectrum. This latter difficulty becomes aggravated to the point of despair when one comes to consider the physics of the corona. As long as one is considering the absorption spectrum of the sun it seems to behave perfectly like a black body of 6,000° K. The spectrum of the chromosphere seems to indicate more intense radiation, and certain lines observed in the corona require a temperature of 1,000,000° for their formation. The rule seems to be that the higher levels in the sun's atmosphere require higher temperatures for the excitation, which is just the reverse of what one would expect on general physical grounds. This fact has led some investigators in the past to suggest that at least part of the excitation comes from the outside. But no satisfactory mechanism of this kind has so far been suggested.

Certain American observers have recently found evidence that portions of the solar disc emit radiations of radio frequencies which are much more intense than one would expect from a black body of 6,000° K. At certain frequencies and under special circumstances the excess is so enormous that it could only be explained by local temperatures up to 1,000,000° K. It appears then that

both in the far ultra-violet and in the regions of very long wavelengths there are serious departures from thermodynamic equilibrium in the radiation of the sun. The physical theories which explain so well the absorption spectrum of the reversing layer, the ionisation there and also the continuous emission of the photosphere from 3,000A to 10,000A, leave no room for the above departures. Only a very drastic modification of existing theories will enable us to understand the radiation of the sun completely.

I cannot leave the discussion of the physics of the solar atmosphere without mentioning the fact that American astronomers had a vacuum spectrograph built into the V2 rocket which was fired at White Sands, New Mexico, on October 10th, 1946. Several spectrograms at different heights were obtained of which the most successful was one photographed at a height of 55 kilometers above the ground. It shows the solar spectrum well beyond 2,400A. Spectrograms of this kind will certainly help considerably to solve the mystery which surrounds the solar emission in the high energy regions.

(3) THE CORONA.

When the Swedish physicist, Edlen, solved the problem of the origin of the emission line spectrum of the solar corona, a difficulty which had baffled astronomers and physicists for 80 years was cleared up. But on the other hand, as was pointed out above, it left astrophysicists with another very difficult problem. Just as previously Bowen had identified the nebular emission lines with forbidden transitions in the atoms of once and twice ionised oxygen and nitrogen, Edlen identified the coronal lines with forbidden transitions in the atoms of Fe, Ni, Ca and A in their 8th to 14th stages of ionisation. The existing theory of solar radiation leaves no room for an agent in the corona capable of knocking so many electrons out of these atoms.

(4) THE OUTSIDES OF THE STARS.

When Fraunhofer discovered the dark lines in the solar spectrum there was some doubt in his mind at first as to whether these lines originated in the sun or in our own atmosphere. This point was soon settled when he succeeded in observing the spectra of some bright stars, because the latter showed spectral lines in quite different positions. Also the stellar spectra differed greatly amongst themselves. There are spectra with practically no lines visible in them, and there are those in which the Balmer lines of hydrogen are fairly intense and only a few metallic lines. Then there are stars in which the hydrogen lines are weaker and the lines due to metals more numerous, and lastly those in which the hydrogen lines are practically or wholly invisible and the spectrum badly cut up by numerous metallic lines and by molecular bands. Saha's ionisation theory attained one of its most notable triumphs when it proved to astronomers that these differences in stellar spectra are not due to differences in chemical composition but are

merely what one would expect if stars with the same compositions were placed in a temperature sequence, from hot to cold.

Long before Saha the Harvard astronomers had classified thousands of stars in classes A, B, F, G, K, M with sub-divisions 1 to 10. To-day we know that the temperatures of the M stars are about 3,000° K., those of the K stars about 4,000° K., the G stars from 5,000°-6,000° K., F stars from 7,000°-8,000° K., A stars from 8,000°-11,000° K. and B stars from 12,000-°25,000° K. There is a small group of stars whose outsides are even hotter than 25,000° K., the O stars and the central stars of some of the so-called planetary nebulae. Astrophysicists talk of the spectra of the hot stars as "early" and those of the colder stars as "late", because the temperature sequence was at one time believed to indicate the line of development of the stars, from very hot to cold.

In 1914 Adams and Kohlschütter working at Mt. Wilson in America detected small differences between stellar spectra of the same type. They were able to correlate these differences with differences in the intrinsic brightnesses of the stars, and eventually used them for the measurement of the distances of certain stars. These so-called spectroscopic parallaxes have been determined for a large number of stars which are too far away for their distances to be measured by trigonometrical methods.

Although the ionisation formula of Saha and modern quantum and atomic theories enable us to get a fairly consistent picture of the physical conditions of most stellar atmospheres on the basis of their observed spectra, it is also true that anomalies exist in many of them, the most common one being the occurrence of lines with high excitation potentials where one would not expect them. Struve of the Yerkes observatory and his assistants have studied these peculiar spectra in detail and made some interesting discoveries. The conclusion seems inescapable that in many stellar atmospheres there is stratification if not of the actual elements then at least of the excitation. Stars have been found which possess enormously extended chromospheres, and it appears that certain close double stars perform their revolutions about each other completely inside such a chromosphere. Cases in which the two components of a binary are in physical contact, with matter streaming from the one to the other, or where the orbit of one component seems to pass through the atmosphere of its companion, have also been found.

His close study of peculiarities in stellar spectra has led Struve to the conclusion that many stars possess high rotational velocities, a fact which seems to have important cosmological significance. Struve finds that stars of early types, B to F5, may have large or small rotational velocities, whereas later types never show high rotations except when they are members of close binaries. Struve asks tentatively whether this means that all late types have got rid of their angular momentum in the same way as the sun may have done when our planetary system was formed.

(5) THE GASEOUS NEBULAE.

Astrophysics attained one of its biggest triumphs in the interpretation of the emission spectra of the so-called gaseous nebulae. About a century ago there were many astronomers who believed that all the nebulae in the sky would some day be resolved into separate stars provided telescopes could only be made large enough. Lord Rosse thought at one time that he had succeeded in seeing with his big reflector the stars which make up the great Orion nebula. The spectroscope, however, left no doubt that nebulae fall into two main classes, those which are made up of groups of individual stars so far away that they appear nebulous even in big telescopes, and those which are made up of glowing gases and are therefore proper nebulae.

These gaseous nebulae, again, fall into two classes, the so-called planetary nebulae, a name given to them by Sir William Herschel because of their more or less regular shapes, reminding one of Saturn and its rings, and the irregular gaseous nebulae of which the Orion nebula is the best known example. In both cases the spectra consist mainly of bright lines, amongst which those of hydrogen (Balmer lines and continuum) and helium (normal and ionised) are prominent. But these spectra contain a number of lines whose origin remained for a long time a complete mystery, and astrophysicists attributed them to an unknown element which they called " nebulium ".

In 1926 the problem of nebulium was brilliantly solved by the American, Bowen, at present the director of Mt. Wilson and Mt. Palomar observatories. Bowen found from his analysis of laboratory spectra that the wavelengths of these lines correspond to so-called forbidden transitions in the atoms of oxygen, nitrogen and neon. So " nebulium " turned out to be hardly different from ordinary air. The reasons why these gases emit the nebulium lines in the nebulae and not in the laboratory is the extreme tenuity and the enormous extent of the nebulae, and the high energy radiation to which they are subject. The amount of gas per cubic centimeter in a gaseous nebula is far less than in the highest laboratory vacuum. On the other hand the diameter of a typical planetary nebula may be as much as 10,000 astronomical units. Before Bowen made his important discovery in connection with nebulium, physicists thought that atomic energy transitions like those giving rise to these lines could not occur, hence the terms forbidden transitions and lines. He therefore succeeded in showing that given the proper physical conditions atoms could perform these forbidden jumps. Bowen himself and others made some further beautiful discoveries in connection with gaseous nebulae, so that the physics of the gaseous nebulae form one of the most interesting chapters in any book on astrophysics. In addition, Bowen's work indirectly led to the identification of the coronal lines.

Gaseous nebulae are stimulated to emission by the high frequency radiation of a nearby star or stars. In the case of the typical,

planetary nebula one always finds an apparently faint star at the centre of the disc. Dr. Zanstra, who spent some years in South Africa and last year became professor of astronomy at Amsterdam, following up the work of Bowen, showed in 1928 how the temperatures of these stars can be determined from the spectra. He found that some of these stars have outside temperatures as high as 100,000° K. Campbell of Lick showed that the gaseous shells of most of the planetary nebulae are slowly expanding, and this has led many astronomers to the belief that they are the remnants of old novae. On the other hand it does not seem to be true that every nova becomes a planetary nebula.

(6) Interstellar Space.

That interstellar space is not quite empty has been evident for a very long time from the multitude of bright and dark nebulae visible in many parts of the sky. In 1924 Hartmann discovered some very narrow absorption lines in the spectra of certain double stars which were stationary and did not share the motion of the stars. These lines could therefore not originate in the atmospheres of the stars but must arise in a gaseous medium lying between us and the star in question. It soon appeared that the spectra of very many early type stars show these interstellar lines. At first only the fundamental lines due to ionised calcium and to neutral sodium were observed and astronomers spoke of the interstellar sodium-calcium cloud which appeared to be fairly evenly distributed throughout the space between the stars. Observations by Plaskett showed that this cloud shared the galactic rotation of the Milky Way, because on an average they showed a motion just one half that of the star whose spectrum was being investigated.

Recent observations have shown that the matter is not quite as simple as pictured above. High dispersion spectra revealed interstellar absorption lines due to NaI, KI, CaI, CaII, TiII and FeI, as well as to the molecules CH, CN and CH^+. Furthermore, Struve and Elvey have recently proved by means of observations made, with a rather ingeniously constructed spectrograph, the existence of faint emissions from many interstellar regions which are due to H, OII, OIII and NII. There are definite indications that hydrogen is very abundant in this interstellar mixture, which seems to be made of the common star stuff.

The atomic and molecular lines due to the interstellar gas can as a rule be recognised at once from their extreme narrowness, as one would expect to find in the spectrum of a gas of very low density. Recently certain very diffuse interstellar lines have been discovered, up to as much as 40A wide. On account of their diffuseness they escaped detection for such a long time. The only reasonable explanation seems to be that they are due in some way to solid particles, which drift around in interstellar space. The occurrence of reflection nebulae in many parts of the sky proves the existence of such solid particles. It is generally believed that

these solid particles pervade the whole of the interstellar region, and that they account for at least some of the general absorption of the light of distant stars.

(7) Stellar Interiors.

In a tribute paid to the late Sir Arthur Eddington, Dr. Shapley, director of the Harvard observatory and leading American astronomer, writes as follows: " Eddington boldly led us into the interiors of the stars. Astrophysics before him was largely the physics of spectroscopy; after him, we could no longer ignore quantum physics and nuclear structure." What we know to-day of the internal structure of the stars, are the results of Eddington's own studies in this connection or of the investigations of other astronomers who were inspired by his work. People maintained and still maintain that it is useless to speculate about the insides of the stars because they will never be observed, and we will never know what it is like inside a star in the same way as we know that Fe is present in the atmosphere of the sun. In spite of this prejudice and the very formidable mathematical and physical difficulties which he encountered, Eddington attacked this problem and his book " The Internal Constitution of the Stars " is still the best introduction to the subject 20 years after its publication.

The most that we can know of a star is its mass, its luminosity its radius and the chemical composition of the minute portion which makes up its atmosphere. The problem of the astrophysicist is to construct a model in whose inward parts the matter behaves according to well established physical laws and which has the observed mass, radius and luminosity. The observed chemical composition of the atmosphere becomes important if it is established that the matter in the actual star is so well mixed that the minute atmospheric portion is a chemically true sample of the whole.

When Eddington conducted his pioneer investigations there existed no satisfactory theory of the origin of stellar energy. Every one realised that the source must be sub-atomic. Fortunately it proved that the models constructed by different investigators were particularly insensitive to the exact distribution of energy sources in the interiors. Since that time, however, Bethe has come forward with the famous " carbon cycle ", a process in which 4 protons successively enter into an atomic nucleus, originally carbon, and after the fourth one has been swallowed the nucleus disgorges an alpha particle and becomes the original carbon, ready to go through the same process once again. In this way one helium atom is formed out of 4 hydrogen atoms and the mass which is lost reappears as energy, according to the relativity theory. It should be noted that the above process can continue indefinitely as far as the carbon is concerned. If the stars contain any appreciable percentage of hydrogen the energy source is powerful enough to keep them shining for millions of years, at any rate

long enough for those astronomers who believe in the so-called short time scale, 10^9 years.

There is some difficulty with the high luminosity stars, which radiate much more energy per gram per second than the dwarfs, like the sun. This difficulty can be partly removed if one assumes that the giants and the super-giants were formed more recently than the dwarfs. But there is another very grave difficulty with Bethe's theory, namely, that the carbon cycle process appears to be very sensitive to temperature, the energy generation increases as T^{17}, and is therefore a highly explosive process. It is difficult to explain why all stars do not explode. But in spite of these somewhat startling difficulties astrophysicists are very pleased to be able to point to a possible source for the enormous output of energy of the stars.

There is a further rather fundamental difficulty in connection with identifying any stellar model constructed theoretically as indicated above with a particular star. One is not sure that by varying certain of the parameters other models with the same mass, luminosity and radius are not possible. And if more than one solution is possible, which one corresponds to the real star? Up to the present astrophysicists have been only too pleased if they could find one particular solution and have not worried much about other possible ones.

But in spite of all the thorny mathematical and physical problems which obstruct the way to a complete solution of the problem of the true state of stellar interiors, studies so far have revealed that the pressures and temperatures inside the stars must be enormous. The temperatures are measured in millions of degrees. Most of the atoms are completely ionised, and all ordinary stars, in spite of mean densities which are sometimes more than that of water, are for the most part perfectly gaseous. There are no absolute proofs that stars have high density (i.e. non-gaseous) cores, but most astronomers are inclined to think so to-day.

A great deal of progress has also been made in the direction of understanding those peculiar stars known as white dwarfs. These are very small stars (sizes of the order of that of the earth) with high surface brightnesses (i.e. high surface temperatures) and about normal masses. The best known white dwarf is the companion of Sirius, whose mean density is 400,000 times that of Sirius, and 50,000 times that of water. One matchbox of the companion of Sirius would weigh ½ ton on the earth. But Kuiper of Yerkes, an indefatigable hunter of white dwarfs, reports a star of mean density 36×10^6 times that of water, i.e. 360 tons per matchbox. The central density of Kuiper's star is 900 million times that of water or 9,000 tons per matchbox. The question of how so much matter—that required to build a good sized freighter —can be compressed in so small a volume, formerly baffled physicists, but the Fermi-Dirac statistics gave us a solution as well as a means of discovering the properties of matter at these

high densities. How the white dwarfs get into this state is hard to explain. On the other hand once they get into this compressed or degenerate state they can apparently never get out of it again.

Another result which has emerged from the studies of stellar interiors is that the stars must be largely composed of hydrogen. Not only is the hydrogen the fuel which keeps Bethe's carbon cycle going, but a high abundance of hydrogen is also required to explain the high gas pressures necessary to support the stellar material against its gravitational attraction. In his early work Eddington did not assume a high hydrogen content for the stars, so that in his models radiation pressure had to account for a large part of the total pressure. To-day astrophysicists believe that radiation pressure is negligible in comparison with gas pressure in stellar interiors.

There is one further complication in connection with stellar interiors which I have not mentioned so far and that is convection. The problem of the internal constitution of the stars is very intricate, and I think I'm correct in saying that the results so far reached bear no relation to the amount of labour spent on the problem. But scientists are a band of optimists and astrophysicists form no exceptions. One looks to the future with confidence knowing that even 20 years from now we'll know a great deal more about stellar interiors than we do to-day.

(8) CONCLUSION.

The fundamental problem in astrophysics is the following, given a certain mixture of elements, and we have a fairly good idea of the approximate proportions in this mixture, determine how it behaves when subjected to pressures ranging from next to nothing up to millions of atmospheres, and temperatures from the absolute zero to millions of degrees, and also when the mixture has radiation falling on it of different energy distributions and dilutions. If this apparently simple problem can be solved completely it would become possible to clear up most of the situations which arise in astrophysical enquiry. Up to the present only very special cases of the above problem have been solved.

But even though the above problem is very far from being solved at present, it is possible to point to notable achievements of astrophysicists during the past century. Astrophysics has stimulated and sometimes taken the lead in investigations of the spectra of the elements in various stages of ionisation. In other fields of pure physics astrophysicists have the discovery of the element helium (1868) to their credit, as well as a notable contribution to the understanding of the so-called forbidden transitions in atoms. Certain energy differences in the states of highly ionised atoms can only be inferred from celestial spectra.

Astrophysics has stimulated research in pure mathematics. I mention just the one example of Fowler's investigation of the properties of the solutions of Emden's polytropic differential equations.

But astrophysics has given us a fairly good idea of the chemical composition of the atmospheres of the planets, of comets, of stellar atmospheres and of the nebular gases between the stars. We even know a great deal about the physical conditions in these different bodies, also in the interiors of the stars.

There is one special case of the above fundamental problem of astrophysics which I met with so frequently during my reading of the recent work in astrophysics that at one time I was inclined to think that it was the great problem itself. It seems to crop up in so many places that I wish to call it the astrophysicist's outstanding problem No. 1. It is the mechanism of the emission lines, and especially the occurrence of emission lines where one does not expect them. We think that we understand fairly well how emission lines are being produced in gaseous nebulae and in novae. We thought we understood their production in Wolf-Rayet stars. But we certainly do not understand their occurrence in the spectra of late type stars. And we have seen that we do not understand how some of them arise in the chromosphere or how the coronal lines are produced. Perhaps the next contribution that astrophysics has to make to knowledge will be the clearing up of this problem.

If at the end of my address you have the feeling that astrophysics has not much to show for all its efforts during the past century, I shall conclude with some words of the late Sir Arthur Eddington, which are characteristic of him and also of the true scientist. At the conclusion of a series of lectures on the origin of stellar energy held in 1928, i.e. long before Bethe's carbon cycle, he spoke as follows :

"I should have liked to close this course by leading up to some grand climax. But perhaps it is more in accordance with scientific progress that it should fizzle out, ending with a glimpse of the obscurity which marks the frontiers of present knowledge. I do not apologise for the lameness of my present conclusion, for it is not a conclusion. I wish I could feel confident that it is even a beginning."

I haven't been able to lead you up to a grand climax, but I hope I have been able to convince you that astrophysics has had a notable beginning.

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COAL

BY

DR. G. N. G. HAMILTON.

Presidential Address to Section "B" of the South African Association for the Advancement of Science.

Delivered, 1*st July,* 1947.

When I survey the list of names of my predecessors in this office, I am very sensible of the high honour that the executive of Section B has done me. In the first instance, therefore, I wish to express my sincere appreciation of this honour.

It is generally accepted that the Union of South Africa is on the threshold of an era of unprecedented industrial development, and that the future of the country lies very largely along such lines. And since coal is the foundation on which such development must be built, I have selected it as the subject of my address with the intention, not so much of passing on information, as of stimulating thought and creating wider scientific interest. Consequently, I trust that in endeavouring to be comprehensive and yet brief in my survey, I may be forgiven some apparent superficialities.

1. COAL DEFINED.

Coal is a rock. It represents original vegetable matter that has suffered changes in chemical and physical properties as the result of geological processes. The main chemical changes are the loss of moisture and volatile constituents such as carbon, oxygen and hydrogen, with an increase in the proportion of fixed carbon and ash. There are also some molecular rearrangements accompanying the changes. The chief physical changes are an increase in hardness and compactness, darkening of colour and the development of fracture properties.

A glance at any sizeable lump of coal shows that it is not a homogeneous rock. There are different types of coals because the several constituents that go to make them up can be present in varying quantities. Thus, all attempts to arrive at a concise classification of coals have met with the same difficulties as have been encountered by petrographers in attempting quantitative classifications of the igneous rocks.

2. THE GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF COAL.

Coal deposits occur in geological formations from Upper Devonian to Pleistocene. In later Pleistocene and recent formations deposits of peat are found. But peat, of course, is not coal.

The coal of Buren Island off the North coast of Norway is believed to be the oldest deposit in the world. It is of Devonian age. Between this and the Pleistocene, there is no geological system but contains coal in some parts of the world. In general and considering the Earth as a whole the Carboniferous System contains the richest higher rank coal deposits, while lignite is characteristic of the Cretaceous and Tertiary. In the Southern Hemisphere the Permian is the most important coal bearer particularly in South Africa, India and Australia. Some of the coals of Europe, Eastern Asia and the United States are also of this period. The Triassic is also a prominent coal bearing system in many parts of the world, notably in parts of Queensland and New South Wales in Australia, Tasmania, Japan, China and Central Europe. In South Africa the Triassic coals are represented by the rather poorer coals of the Beaufort and Stormberg Series.

In China and Korea the Jurassic System becomes of considerable importance. The Upper Cretaceous is almost comparable with the Carboniferous in being one of the great coal bearing periods in the Earth's history. This period of deposition continued into the Tertiary and accounts for most of the world's lignite.

Geographically, there are very few countries in the world which do not have some coal. Egypt and Tibet are, I believe, without coal deposits and, no doubt, one or more of the South American countries could be added to this. Switzerland and Norway have very little, and such countries as the Argentine Republic, Brazil, Sweden, Italy and Japan have totally inadequate resources within the confines of their boundaries. Reference to maps showing world coal resources or to tables of estimated reserves, reveals that the South American and African Continents are in proportion to their sizes, very poorly supplied. Of course, further discoveries may change this impression radically. The Union of South Africa may be regarded as reasonably, though not lavishly endowed. In attempting any survey of the world's coal resources one is impressed by the necessity of an early revision. Researches and exploratory work during the past decade in particular must have furnished much new material requiring collation. There is, for example, no extant factual information about the coal resources of Asia in general and of China in particular. It is believed, however, that the potentialities of China are immense, particularly in regard to anthracitic types of coal. An appreciation of the distribution of coal deposits must have an important bearing on an understanding of the future economic developments of countries and of commercial relationships between them.

3. The Nomenclature of Coal Petrology.

Coal seams show variations in what are termed *rank* and *type*.

That the solid fuels constitute a continuous series beginning with peat and passing through lignites, sub-bituminous coals, bituminous coals and semi-anthracites to anthracites, is well known

and equally generally accepted. This nomenclature is descriptive of *rank* ; thus lignite is a *low rank* coal while anthracite is of *high rank*.

It is likewise well known that a single seam of coal invariably displays a banded structure, each band differing in such physical properties as hardness, fracture and lustre. Each also differs in chemical composition. These different bands are different *types* of coal; and it is known that type is dependent upon the kind of plant material from which the coal was formed.

Type is, therefore, an inherent characteristic of the coal, while rank is descriptive of the degree of alteration of the original peats as a result of geological processes. In general, the older coals are of higher rank.

It is proposed here merely to survey in brief the modern conception of coal types and their classification based on petrographic conceptions.

The method of investigation is based almost entirely on the microscopic examination of thin sections, the preparation of which demands a very high technique. For the higher rank coals the use of polished blocks (Analogous to the methods of metallography and the study of opaque minerals) has also been successfully applied.

The term "maceral" is used to embrace all the constituents that go to compose coal seams. It is therefore analogous to the term "mineral" used to refer to the constituents of rocks. Thus, a coal type will depend essentially on (*a*) the macerals that constitute it and (*b*) their relative abundance.

The lithological terms of almost general acceptance are vitrain(-ite), clarain(-ite), durain(-ite) and fusain(-ite).

The type *vitrain* is characterized by occurring in clear-cut, uniform, brilliant black bands and lenticles from a fraction of an inch up to several inches in thickness. It consists mainly of the maceral vitrinite (collinite and tellinite) and may contain very small quantities of others such as fusinite, micrinite and exinite. It forms the major portion of "bright coal" and has been derived from the woody tissues of plants (wood and bark).

It is, with clarain, of considerably lower specific gravity than the others. It is the best coking constituent of coal. It would appear to correspond to the Anthraxylon of American nomenclature.

Clarain is described as bright streaky coal with a silky lustre. It has not been generally accepted as a distinct type of coal by some petrographers while others regard it as the type bright coal. It consists mainly of *vitrinite* and must contain small quantities of other macerals, notably exinite.

Fusain is the porous, charcoal-like material in coal. It is greyish-black in colour and soils the hands. In thin section it appears as irregular masses of cellular tissue with opaque cell walls. The cells are frequently filled with mineral matter. It has no coking

properties of itself. It is composed essentially of the maceral *fusinite* but may contain small quantities of the other macerals.

Durain is the hard, dull, compact coal found usually in thickish bands. It only displays visible lamination when thin bands of vitrinite come in. In thin section it is much more opaque than the others due to the high proportion of the macerals, micrinite and exinite. Megaspores and microspores are commonly abundant while resins and finely macerated plant materials occur in variable proportions. Thus, Durain (and this means the "dull" coals in general) shows much greater variations in constitution (also, hence in chemical composition) than do the vitrinite ("bright") coals. It is considered that this coal was formed during periods when the peat was inundated, so that the normal peat formation, resulting from the accumulation of vegetable debris derived from plants growing *in situ*, was replaced by a mud derived from the peat itself and very finely comminuted plant and mineral matter washed in. This coal consequently contains a high proportion of sedimentary mineral matter.

In concluding this brief survey of the petrographic constitution of coal, there is one more point. The microscope reveals that in coals of all ranks of the same age, the same microstructures and the same types of coal occur. Hence differences in rank in coal are not the results of inherent differences in the nature and composition of the original peats.

The above types when considered as the "bright" (clarain type) and "dull" (durain) coals are the normal coals, and are usually associated as layers constituting a seam.

In addition, however, there are the *cannel coals*. These are characterized by their compactness, greasy and dull lustre, absence of banding and resemblance on striking to hard, dense wood. They fracture conchoidally. The vegetable matter composing them (as in durain) is so finely broken up as to beggar identification in greater part. Since fusinite is invariably absent, the vegetable matter is translucent in thin section. Spores, resins and portions of cuticles can be identified. Shreds of vitrinite are often present. There are all transitions through to the "bright" coals on the one hand by the increasing of the vitrinite content to the "dull" coals by increase of fusinite and micrinite.

The *torbanites* (*bogheads*, *oil-shales*) may be regarded as a variety of cannel arising by the incoming of algae. With increase in the quantity of algae the colour changes from black to brown and the rock becomes softer. On distillation they give a high yield of oil consisting of a mixture of various members of the paraffin and olefine series. They are regarded as having been formed from muds which accumulated in lakes in the peat swamps.

The *mineral* matter in coal—expressed as "ash" in chemical analyses—is described as "inherent" and "adventitious" or "sedimentary". All plants contain a certain amount of mineral matter as part of their constitution. This is not observable under

the microscope and is considered as representing about one (1) per cent. of the total ash. The adventitious ash represents finely divided clay substances deposited among and along with the plant material and later minerals deposited from percolating solutions. The former may occur uniformly disseminated throughout the coal substance in which case it can not be removed by washing. This is commonly the case in the "dull" coals and cannels. On the other hand it may be segregated into shaley bands or partings and can, therefore, be removed or reduced in amount by a cleaning process. The jointed nature of the "bright" coals lends itself to the latter type of mineral introduction and the occurrence of "ankerites" (mixed carbonates of calcium, magnesium and iron) in the form of thin veins in such coals is common. Pyrite is also of common occurrence in this way but it has also been observed in disseminated small blebs through the coal substance apparently replacing a constituent. Finally, ankerites and pyrite are also found as the infilling of the cell cavities of fusinite. A considerable increase in the quantity of adventitious matter in "dull" coals, marks the transition into carbonaceous shales.

As the heating value of a coal varies inversely with the ash, it is obvious that an appreciation of the occurrence of this ash can be of assistance in the devising of the means of cleaning coal and thereby enhancing its value.

A study of analyses of South African coals shows that their ash content is high. Little is known, however, of the actual nature and mode of occurrence of this ash, and I suggest that microscopic study would materially assist in arriving at some methods of cleaning and treating higher ash coals so as to render them economically usable.

The application of the microscope to the examination of thin sections of coals has made great advances of late in Britain and America. With continual refinements in technique it is becoming more and more an essential part of the normal equipment of the geologist and fuel technologist, and has already proved of great value to the industrialist. In South Africa this has been a neglected field of work. There are many peculiarities of our coals, for a proper understanding of which it has now become necessary to introduce microscopic work. This is a wide new field of research in South Africa crying out for many young and enthusiastic workers, and it is to be hoped that our Universities, in particular, and the Fuel Research Institute certainly, will turn their efforts in this direction. The petrographic work in Britain and America has been confined largely to the study of the Carboniferous Coals deposited under similar conditions and composed of similar plant remains. The Permian coals of South Africa with their differing conditions of deposition and plant types must be the source therefore of many new contributions to science.

4. The Chemical Constitution of Coal.

A chemical analysis of a coal is generally recognized as the best means of determining its commercial value. The value of such an analysis, however, is a function of the method of sampling. The uninitiated invariably overlook this and their sampling consists in selecting a few odd lumps of what to them is the best looking coal. Standard methods of analyses are recognized in most countries of the world; it is just as desirable that uniform systems of sampling be instituted. The American Society for Testing Materials (A.S.T.M. Standards) and the British Standards Association set out what may be described as standard methods; either of these might well be adopted, but certainly no certificate of analysis of a coal should be issued without reference to the method by which the sample was taken.

A *Proximate Analysis* furnishes most of the data required for assessing the quality of a coal. This involves the actual determination of moisture, volatile matter and ash; fixed carbon is calculated by difference. Such an analysis is invariably supplemented by determination of the heating (calorific) value of the coal, the coking properties and the ash fusion temperature. In order to get results from which comparisons can be drawn, the figures are usually computed to a dry-ash-free basis. It is always advisable to determine sulphur.

An *Ultimate Analysis* involves the estimation of ash, and the five elements carbon, hydrogen, nitrogen, sulphur and oxygen.

Although both analyses give considerable information of the properties of the coal, they give little about their actual chemical constitution. Other methods involving extraction with solvents prior to analyses have to be adopted in order to try to gain further information. But this has its distinct limits.

Coals have been shown above to consist of different types. Analyses show that each type has, within a certain range, its own peculiar chemical composition and properties. Any variations are the result of the differences in the proportions of the various components.

The following few points may serve as a brief illustration of some of the chemical characteristics of each type.

Vitrinite is mainly characterized by its low ash and this ash has a red colour. Bright coals (vitrinite rich type) yield more volatile matter than dull coals unless the dull coals are very rich in spore material. Bright coals yield a stronger and higher swelling coke than dull coals; the latter seldom coke at all and, if they do, they yield granular and very slightly swollen masses. This latter behaviour is the result of the high proportion of fusinite and micrinite in durain. While, therefore, it may be concluded that all dull coals are not good coking coals, it can not be accepted that all bright coals are.

There is no great difference in the calorific values between clarain and durain types and the value of each approximates to

that of the whole seam. Bright coals may be slightly higher on the average but this condition is reversed if the durain is rich in spores. As has already been indicated, the dull coals have a wider range of composition than the bright, and this is reflected in their chemical properties, particularly in the hydrogen content. Both show considerable variation in their carbon and oxygen content. These variations are not an inherent character of the coals, however, but rather a function of geological processes and, therefore, a measure of the rank.

The cannels and bogheads, as compared with the normal coals, show a much lower proportion of fixed carbon, and much higher amounts of volatile matter. Their hydrogen content is also greater and averages about 10 per cent. as against about 3 per cent. for the normal coals.

Finally, in assessing the value of a coal from its analysis, no single factor can be divorced from any of the others. Each has its own significance and makes its own contribution to a final assessment. Too frequently, it would appear, is the assessment of the commercial value of a coal made a function of its calorific value.

5. Ranks of Coals.

Since the solid fuels form a continuous series with imperceptible gradations between the members, there is the greatest difficulty in sorting them out into definite groups. As suggested above the main difficulty arises from the fact that the properties of coals can not be definitely correlated with their chemical compositions.

None-the-less a coal can usually be assigned to an approximate position in the series (peat), lignite (or brown coal), sub-bituminous coal, bituminous coal, semi-anthracite and anthracite. The term " rank " is used to define the position of a coal in this series. It is not an inherent property of the coal but a function of geological processes—a measure of its maturity.

Lignites (or brown coal) are the lowest rank coals. They occur in Mesozoic and Tertiary formations and may be of considerable economic value. They vary in texture from claylike to woody and in colour from brown to black. Frequently they contain wood fragments in considerable quantity and of large size. Lignites burn readily with a long smoky flame. On account of the usual high moisture content they crumble on exposure. They are very liable to spontaneous combustion.

An average analysis gives :—

Moisture	14·5 per cent.
Volatile matter	41·0 per cent.
Ash	9·0 per cent.

The calorific value in B.T.U. on a moisture-and-ash-free basis is from 10,000-11,000, and the specific gravity 0·5-1·3.

In South Africa Lignites occur at several localities in the coastal belt in Cretaceous and Tertiary beds.

Sub-bituminous coals are also low rank and usually of Mesozoic or Tertiary age. They display all variations in degree of lamination and lustre between the lignites and the bituminous coals. The moisture and volatile contents are both high as also the ash. Such coals are very suitable for the production of illuminating and producer gas but their ready " slacking " (crumbling on exposure to air) militates against their transport over any distance. The calorific value is usually of the order of 8,000 B.T.U. It would appear that the coals of the Molteno Beds, where unaffected by igneous activity, are of this rank, but as their volatile matter content is invariably low, the term semi-sub-bituminous is suggested as probably more appropriate.

The *Bituminous Coals* cover a very wide range and include all types described above as the " normal coals " and the cannels. They may be coking or non-coking. Coking coals have the property of softening and running together at the temperature of incipient decomposition and of giving a hard grey cellular mass (coke) on quenching. A simple preliminary test of coking properties may be carried out by rubbing the coal in an agate mortar with a pestle. Coals which coke cling to the side of the mortar. In general, however, the " swelling index " is a reliable measure of coking properties. The average specific gravity of bituminous coals is 1.3 while the calorific value is from 12,000-14,500 B.T.U. An average analysis gives :—

Moisture	2-10 per cent.
Volatile matter	25-40 per cent.
Ash	5-12 per cent.

The coals of the Coals Measures of South Africa (the Middle-Ecca) are bituminous. But it becomes necessary, having regard for their invariable higher ash content (and consequent lower calorific value) to apply some modifying term. For the Witbank (Eastern Transvaal in general) coals, the description as " high-ash bituminous " might be appropriate, while the terms " semi-bituminous " or " low volatile bituminous " (having regard for the usual lower volatile matter content) would appear to be apt for the Natal coals. Such terminology implies that the Natal coals are in general of higher rank than those of the Transvaal; which is considered justified.

Semi-anthracites may be considered as occupying a position in the series between the semi-bituminous and the anthracites, both in physical characters and chemical composition. Thus, for example, the volatile matter lies between 6 and 11 per cent.; moisture about 2 per cent. and ash 9 per cent. in good grades of this rank.

The coals in South Africa frequently described as anthracites approximate to this class although their invariable higher ash content and physical characters might justify the use of the rather cumbersome term " high-ash-semi-bituminous ". In some few cases, however, the term semi-anthracite seems justifiable: in no

cases, within my own knowledge or experience, is the term anthracite applicable to South African coals.

Anthracites are the highest rank coals characterised by their bright to sub-metallic lustre, non-soiling property, conchoidal fracturing and hardness. An average analysis (to quote again the three items selected above) gives :

Moisture	3 per cent.
Volatile matter	4 per cent.
Ash	7 per cent.

The specific gravity is very variable (1.27 to 2.2 are recorded) while the calorific value is from 14,500-15,000 B.T.U.

(NOTE.—In endeavouring to give figures to illustrate compositions in terms of "average" analyses, an approximate average of averages taken over results from many sources has been employed. Consequently a too literal interpretation is not applicable and the figures must be viewed as mainly illustrative.)

To sum up, the following are some of the main points indicative of increase in rank :

(*a*) Increase of lustre, hardness, specific gravity, calorific value and fixed carbon content.

(*b*) Decrease of lamination and mineral matter, volatile matter, moisture and oxygen content.

As a result of many lines of investigation, which time and space do not permit of reviewing even briefly, it has been conclusively proved that the rank of a coal has no connection with either the type of the coal constituting a seam or with the state of preservation of the original plant material. It is the response of the vegetable matter to its geological history—that is, external influences. For example, it has been shown that in a vertical succession at any point in a coal field the rank of the coals increased with the depth. So very few exceptions to this have been found that the conception is known as Hilt's Law. Thus, in general terms, rank change is induced by pressure and temperature changes due to overlying strata. In the case of heat and pressure generated by major earth movements, it has also been shown that rank change is effected in the regions of maximum effect, namely, in the vicinity of the flanks of the folds and not over the axes. Increase of rank is also sometimes brought about by igneous intrusions.

The general higher rank of the Natal coals as compared with those of the Witbank field, for example, is therefore, explicable on the basis of the greater development of the Middle and Upper Ecca beds in that province. Since increase in rank is an irreversible process, the one-time equal development and subsequent unequal erosion (greater in the Transvaal) of the Ecca beds in the two areas may be dismissed. The semi-anthracites, which are particularly abundant in Natal, are due to increase in rank by igneous intrusion. In a few localities in the Eastern Transvaal some notable, but apparently very localized, increases in rank by dolerite intrusion

have been personally observed. It must not be assumed that the influence of igneous intrusions on coal seams is, of necessity, an adverse one.

6. Some Notes on the Origin of Coals.

It is not proposed here to enter into any detailed survey or to offer any comprehensive account of this subject. Rather is it intended to make some random suggestions on some of the broader aspects in so far as they have presented themselves to me in the course of some recent observations, particularly in many parts of Natal.

The succession of strata constituting the Ecca Series, differs considerably from those of the principal Coal Measures of Europe and America. In Britain the Carboniferous Series is a record of a full cycle: subsidence of the land mass to a marine basin with the formation of marine limestones (carboniferous limestone)—continuous sedimentation with the formation of lagoon limestones, marls, etc. (Yoredale Series)—continued sedimentation with consequent shallowing and silting up and the arising of deltaic conditions (Millstone Grit)—the development of estuarine swamps with conditions under which vegetation could grow (Coal Measures)—uplift, with the formation of the Permian continental mass. In South Africa the deposition of the Ecca beds followed upon the northward retreat of the Dwyka glaciation. In Natal the lower and upper Ecca beds are composed of very fine sediments indicating deeper water deposits. The absence of marine fauna in conjunction with the lithology suggests fresh water conditions. In the Middle Ecca (coal measures) shales are comparatively scarce and the main deposits are sandstones and grits with some thin, small pebble bands. Some of the grits are felspathic in character but grits in general are not plentiful. They also seem to occur mainly above the coal seams. Most of the shales (with the exception of those in immediate association with the coal seams which are distinctly carbonaceous and grade into cannels, are inclined to be sandy and seem more accurately describable as fine-grained laminated micaceous sandstones. The coarser grained sandstones are strongly current-bedded and there are rapid gradations from coarse to fine sediments. The finer sediments are all in varying degrees carbonaceous and peculiarly mottled. Sandstones come in in layers up to several feet in thickness. Fossils are extremely scarce. No suggestion of any marine or fresh-water fossils has been observed. It is admitted in this regard that any close examination of the finer sediments in which fossils are most likely to occur has been limited very largely to bore-hole cores. The above sequence is to be regarded as characteristic of very shallow water or estuarine swamps. The rhythmic alterations of fine and coarse sediment suggest the periodic rejuvenation of the rivers transporting the sediment. This would appear to be due to changes in climatic conditions rather than to uplift.

Each of the coal seams is composite both as to the arrangement of the coal and non-coal bands and as to the coal itself. And it is

remarkable how consistent this is over comparatively large areas. There is thus little difficulty in correlating the seams on this basis over limited distances of the order of 26 miles.

The parting between the two seams varies from a few inches up to over 60 feet. This change may take place over a comparatively short distance. Within a distance of about three miles, for example, the parting goes down from 42 feet to 4 inches and then increases up to 61 feet. Each of the seams, however, although varying slightly in width, maintains its general character in spite of the splitting. In other cases the splitting becomes much more complex so that it becomes difficult, if not impossible, to trace each separate seam back to its parent. In an unworked field where one's observations are limited to very sparse and widely separated outcrops and to equally widely separated bore-holes, it is almost impossible to reach definite conclusions, but I have the impression that in some cases the bottom member of a seam in one place has become the top layer of another seam at another place, and a separate entity at yet another. The cause of this splitting of seams would appear to be due to differential subsidence due to varying abilities of the floor to support its burden. Thus down-folding takes place and the one portion of the accumulating peat-bed begins to sink while the other portion remains stationary at the normal level of the swamp. The infilling of this depressed portion has to be completed before the conditions for normal peat accumulation can be restored. Thus, such splitting must be viewed as of localized extent in areas where there is no evidence of major earth movement. It may also be that the general structure of a large coal-field may be conceived as constituted of a number of such basins originating in this way. When, however, the thinning out of the seams is accompanied by a deterioration in quality, and the incoming of dirt bands, the explanation must be different. Such a change would indicate that the edges of the original swamp were being approached and that the seams must ultimately peter out when followed in that direction.

There is yet another type of split or interruption of coal seams which is to be accounted for by contemporary erosion. These are the familiar "wash-outs" and their mode of origin requires no enlarging here. In investigating any coal-field, however, this may well provide the explanation for an area of no coal, especially when such area appears to be of limited extent.

It is a matter of great difficulty in considering the Coal Measures of Natal and elsewhere to say where one coal-field begins and another ends. And when one considers the many factors that can operate to bring about the splitting of seams, the problem becomes greater. It would appear that there is very little justification for the dividing up of a coal-bearing area into fields purely on the basis of the number of seams, especially where such fields are contiguous and there are no apparent stratigraphical breaks.

The fact that impresses itself most on one's mind is the vast area of the coal-bearing strata. That coal deposits originated from vegetation that grew in swamps is generally accepted. The difficulty has always been to try to find a modern parallel for these ancient swamps. The great Dismal Swamp of Virginia is frequently quoted as more nearly representing the kind of accumulation of vegetation which could give rise to extensive coal seams than many others. The total area of this is over 2,000 square miles. But even this is regarded as far too small. The North Sea area was presented as a possibility by the late Professor Kendall and this parallel is of special appeal to South African students because of the many analogies that can be drawn with our own Coal Measures. At some period subsequent to the Pleistocene Ice Age the Southern portions of the North Sea, as a result of the effects of glacial erosion and deposition, existed as a vast plain so close to the then sea-level that it became a morass. Thus the greater part of the area became a vast peat swamp cut by many rivers and their tributaries. In like manner the vast areas of our own Coal Measures may have found their origin. Subsequent to the Dwyka glaciation (the beginning of the Ecca) a large area of low-level morass was left with higher land to the East and North. Subsidence led to the development in the southern portion of deeper water conditions until deposition (Lower Ecca) again restored Estuarine conditions. Then began the development of the vast peat-swamp from which the Coal Measures would be formed.

7. The Efficient Use of Coal.

History has shown that accessibility of large coal supplies is an essential factor in the great industrial development of any country. Even if we are beginning to think in terms of atomic energy, it must be remembered that developments in the utilization of coal also progress rapidly, and the coal technologist is never relaxing his efforts to meet the demands of industry. The future of coal as an essential factor is assured. But accessibility need not of itself be everything. It is of the utmost importance that the best use should be made of the coal that we possess.

The efficient use of coal embraces three main aspects :

(*a*) Efficient exploitation.
(*b*) Efficient marketing.
(*c*) Efficient using.

With regard to (*a*) I can do no better than suggest that many valuable lessons are to be learned from the 1945 Report of the Technical Advisory Committee on Coal Mining to the British Ministry of Fuel and Power.

Efficient marketing implies broadly the uninterrupted provision of the right sort of coal to the consumer at the lowest possible price. It would appear that in a young country facing industrial expansion and at the same time likely to be called upon to meet an ever-increasing export trade, that private enterprise must provide

the driving power but that there must likewise be some co-ordinating control.

With regard to efficient using, it is proposed to conclude this address with a brief survey of the main uses of coal.

One of the main uses of coal is the production of metallurgical coke used mainly in the production of pig iron. The coal should have a low ash and sulphur content, be strongly coking and yield a strong but porous coke. Such coking coals are probably limited in quantity. A survey of known reserves is at present one of the terms of reference of a Coal Commission. The computation of reserves or potential reserves is no easy matter. It is interesting to note that in computing the coal resources of the world, calculations had regard for seams of 1 foot in width down to a depth of 4,000 feet and of 2 feet down to 6,000 feet ! It is certainly advisable that wherever possible the best coking coals should be reserved for metallurgical purposes. The main competitor is in the manufacturing of town gas but it is probable that research will lead to the commercial manufacture of town gas of good quality from non-coking coals. In the meantime the weaker coking coals towards the higher-volatile end of the group are the most suitable and should be reserved for this purpose. The further importance of the coking and gas-manufacturing industries is the great value of their by-products.

The raising of steam in a boiler in order to operate an engine is also a most important use for coal. Such a coal must have a high calorific value, be sufficiently high in volatile matter to be free burning and not be strongly coking. The ash content should be low and the ash have a high fusion temperature. The semi-bituminous coals have been recognized for long as the best steam coals.

Coals for cement and tile and pottery burning are the low-sulphur bituminous coals.

The use of pulverised fuel is coming more and more into use for steam raising purposes. The coal is ground exceedingly fine and then blown into the furnace with an adequate supply of air to ensure its complete combustion. The bituminous coals are the most suitable.

Domestic consumption amounts to large tonnages each year, averaging about 2 million. Domestic coal should be low in ash and have an adequate calorific value. It should contain sufficient volatile matter to ensure ready but not too free combustion and at the same time to keep down smoke nuisance. Local supplies, however, are the main governing factor. I sometimes think when I look at the grim efforts to ignite of some of the coal put on my own fire, that the domestic supply is sometimes met from coals that have no uses, and therefore no market, elsewhere.

In conclusion, there is no industry in South Africa that calls for more vision and enterprise than the Coal Industry. It has the right, however, to expect all encouragement and the minimum of interference compatible with efficient control.

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THE PROBLEM OF COTTON PRODUCTION IN PORTUGUESE AFRICA

BY

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Presidential Address to Section "C" of the South African Association for the Advancement of Science.

Read 2nd July, 1947.

Before discussing the problem of the production of cotton fibre in the Portuguese African possessions—to-day one of the most important raw materials in the world—I wish to make a few remarks about the actual position of the cotton problem.

From 1935 to 1944 the average annual cotton production in the world has been nearly six and a half million tons which at present prices represents a value of roughly one thousand million pounds. If we add the value of the cotton seed calculated as about one hundred million pounds we shall realise that as compared with other textile fibres cotton is by far the most important.

From 1933-37 more than 56 per cent. in weight of the fibres used in the world were from cotton. Wool consumption was less than 8 per cent. of the total; rayon and other artificial fibres were less than 5 per cent. and silk less than 0·5 per cent.

This great development of cotton consumption is a very recent historical event. Till the second half of the 18th century, the most used fibres were wool, flax and silk. Cotton began to be a big crop in the first years of the last century as a consequence of the invention of the cotton gin in the U.S.A. and the industrial revolution in England. The use of machinery for the ginning of cotton and the manufacture of cloth and the introduction of the steam engine into the textile industry, concentrated in big factories, reduced in such a degree the need for manpower, and consequently the production cost, that cotton soon took the first place as a textile fibre.

The centre of production then moved gradually from India to the United States of America.

When Whitney invented the cotton gin in 1793, the U.S.A. production had not reached 10,000 bales per annum, but at the end of the 18th century the production exceeded 100,000 bales, and in 1892 the U.S.A. were producing more than 9,000,000 bales, i.e. three-quarters of the total world production. In one century production in the U.S.A. had multiplied a hundredfold.

In 1904, for the first time, the level of 20 million bales (over 4·3 million tons) was exceeded, and in the last ten years the production has been nearly 30 million bales (almost 6·5 million tons) per annum.

Consumption, however, did not keep pace with this continuous increase in production. The carry-over, which in 1920 was 2.3 million tons, increased to 4·4 in 1940 and attained 5·5 million tons in 1945.

In 1933, for the first time, the cotton crop of the U.S.A. was smaller than the combined crops of other countries. Since 1925 cotton production decreased in the U.S.A. while it increased continuously in the rest of the world. In the last ten years the U.S.A. production has been about three-quarters of the combined crops of other countries.

As production costs are much lower in many cotton countries than in the U.S.A., American cotton can hardly compete in price with foreign cotton. Before the last war, the cotton problem became one of the most acute economic problems of the U.S.A. The war brought, with its large needs of cotton and consequent high prices, a provisional solution to the problem. It is, however, probable that in the next few years prices will drop again as they did after the 1914-18 war and the economic struggle for markets will become more and more intense.

In spite of the efforts of the successive Portuguese Governments, the production of cotton in our African Colonies was economically very low up to the end of last century. During the civil war in U.S.A. the abnormal and sudden increase in cotton prices stimulated for a few years cultivation in Angola. In 1872, that Colony exported a little more than 873 tons of fibre. After the war the prices dropped suddenly again to their normal levels and cultivation was almost abandoned. In 1878, the export of cotton from that Colony did not attain 19 tons.

After the proclamation of the Portuguese Republic in 1910, several economic measures were taken to stimulate the cultivation of cotton in the Colonies. The production and the selling of alcohol were prohibited; the technical services of the Department of Agriculture were organized; experimental stations were established; in certain regions the growing of cotton became compulsory for the natives, buying prices for cotton-seed were fixed by law; the civil administrators were ordered to buy all cotton produced and the natives were allowed to pay their taxes with cotton.

As a consequence of this policy, production began to increase slowly but surely. The raising of prices, which accompanied and followed the first great war, also stimulated the cultivation of cotton in our Colonies, so that the average annual exports from Angola between 1922 and 1926 were 655·8 tons; and in 1924 Mozambique exported 1,527 tons.

However interesting these results may seem, the Colonial cotton production remained insignificant in relation to the needs of our

national textile industry. In 1926, when prices had already dropped to the normal pre-war level, the pooled production of Angola and Mozambique did not reach 3,000 tons. Up to 1932, more than 90 per cent. of the imported cotton in Portugal came from foreign countries.

It was in 1926 that cotton legislation, which is still partly in force, was promulgated. This legislation established the following principles: viz., the creation of cotton zones in which holders have the exclusive right of buying the whole of the native production at prices fixed by the Government; the holders are compelled to buy, to gin and to export all the cotton produced in their zones, to distribute selected seeds to the natives and to promote the practice of the most suitable cultural methods; compulsory cultivation by the natives in the cotton zones was simultaneously established.

In spite of these measures, production remained steady between 1926 and 1932. This must be attributed to the tremendous fall of prices during that period. As a matter of fact, in 1932 the cotton prices on the New York Exchange dropped to the low level of threepence per pound.

It was then in 1932 that the Portuguese Government established a minimum price of 8·72 pence per pound for colonial cotton on the Lisbon market. Whenever American quotations were lower than that fixed by our Government, the State balanced the difference by means of a so-called "export premium".

In 1938, the Cotton Export Board (Junta de Exportação do Algodão Colonial) was created for the purpose of co-ordinating the production and distribution of cotton of our Empire. A Technical Department of the Cotton Board was organized with the object of studying the problems relating to cotton production—selection of the most suitable areas, of the best varieties, of the most adequate cultural methods, study of cotton pests and diseases, etc. This Department appointed experts and organized experimental stations in Angola and Mozambique. Later, in 1943, the Cotton Board created a scientific research centre (Centro de Investigação Científica Algodoeira) which undertook the study of all the problems related to cotton production.

Since 1932, the year of the lowest cotton prices, the world consumption of cotton increased rapidly. It jumped from 5 million tons in 1932 to more than 6·5 millions in 1937. Everybody felt the approach of the second world war and therefore great stocks of raw materials were stored. Prices began to rise again, slowly at first and at a greater pace since 1938.

All these circumstances contributed largely to a rapid development of cotton growing in our Empire, especially after 1935.

On the other hand, since the prices of the world market attained the minimum fixed by the Portuguese Government the State was liberated from the burden of the export premium.

The results of this policy are clearly seen in the following Table which shows the average annual exports of cotton fibre from Angola and Mozambique by five-yearly periods since 1927:

EXPORTED FIBRE IN THOUSAND TONS.

	Angola.	Mozambique.
1927-31	·580	1·571
1932-36	1·207	2·658
1937-41	3·835	6·628
1942-46	4·455(1)	20·012

(1) This figure refers to the period of 1942-45 on account of the unavailability of data for 1946.

In order to have an idea of the relative value of these figures it is interesting to compare them with those of some neighbouring countries. From 1940 to 1945, the Anglo-Egyptian Sudan produced an annual average of 56,600 tons, Uganda 42,800 and Tanganyika 8,200 tons.

During the last five years Angola and Mozambique together exported an annual average of more than 24,000 tons. All this cotton was consumed by the Portuguese textile industry.

The contribution of the Colonies in supplying the national market, which till 1932 was always below 10 per cent. of the total imports, increased since 1943 to almost 90 per cent. of the consumption of fibre.

A sufficient national supply has almost been attained, since the country's needs of foreign cotton do not exceed now more than one or two thousand tons of the long stapled fibre which is not yet produced in our African provinces.

The benefit resulting to our trade balance from the fact that we no longer need to import annually 24,000 tons of cotton amounts to more than 3·5 million pounds.

The quality of our fibre is fairly good. The average staple of Mozambique cotton is $1\frac{1}{8}''$; Angola cotton is a little shorter, varying between $\frac{15}{16}''$ and $1\frac{1}{8}''$.

The average yields are rather low—190 pounds of seed cotton in Mozambique and 199 pounds in Angola are obtained per acre.

The varieties actually cultivated are derived for the most part from Barberton varieties. In Angola the Triumph Big Boll is still under cultivation in one of the zones.

Brilliant as these results may appear, it must be born in mind that they were greatly due to the rise of prices as a consequence

of the war which acted as a protective Customs Duty, so to speak, under which it was possible to develop the colonial cotton cultivation without the necessity of resorting to protective measures against foreign competition which would necessarily bring about economic retaliations.

In this battle for cotton production, the first round was won, while a balance was brought about between the needs of our textile industry and the output capacity of our Colonies. The prices, however, in the world market will tend to drop in the next few years.

The problem is now to study the production and transport conditions in order to be able to meet the fall of prices which is drawing near. It is necessary to avoid the use of protective Customs Duties with their undesirable consequences; and, on the other hand, the Nation must be spared the heavy burden of a high export premium, which would become unbearable if established permanently. The next round in the cotton battle will therefore be a struggle for the reduction of the cost of production.

It may seem strange that the cost of production is so high in a country where land has a low value, climatic conditions are apparently very favourable and labour is abundant and inexpensive. The reasons for this result are: In the first place, that cultivation is carried out by natives with a very low living standard; that the growing of the crop is entirely manual without the aid of any farming implements; that small native plots of scarcely more than 2½ acres are cultivated; that the soil is sometimes not at all suitable for the crop; that the available meteorological data are not sufficient to allow of a definite selection of the more favourable areas climatically.

Further, the damages caused by insect pests are sometimes enormous. Jassids are so abundant and frequent that it is not economic to cultivate non-resistent varieties In this particular direction the Barberton Experimental Station rendered us priceless service by supplying us with Jassid-resistent varieties selected there. The Red Boll Worm, the Stainers, the Pink Boll Worm and sometimes Hellopeltis cause great damage, and are often very difficult to control.

All our cotton is cultivated on dry land; cotton is not yet grown under irrigation in our territories. In certain zones, the rainfall is too high; in others too low; and yet, in those where average rainfall is suitable for cotton growing, the distribution through the year is sometimes so irregular that it is difficult to foresee the best planting season.

Under these circumstances, the yields are low and irregular.

They may exceptionally reach more than 1,000 pounds seed-cotton per acre but they may also drop to as low as 100 pounds and even less per acre. The average yields in Mozambique are about 190 pounds seed-cotton per acre and in Angola about 199 pounds.

On the other hand, both land and sea transport are excessively expensive.

Finally, in the biggest producing countries nothing is wasted. Cotton seed is completely utilized in the forms of edible and industrial oils, cattle-feed, etc. The linters and hulls themselves have recently found a large industrial use. This industrialization on a big scale of the seeds reduces considerably the cost of production of the fibre and automatically increases the profits of the growers.

Owing to the difficulties caused by the war, it has not yet been possible to benefit by the industrial utilization of the seeds. However, the 1946 legislation already compels the cotton zone holders to utilize the seeds and the first factories are being erected for the extraction of oils.

All these problems are being dealt with and some of them are nearly solved.

Our aim is to be able to supply the Portuguese textile industry exclusively with cotton produced in our African provinces.

We are now very near the goal and I am convinced that we shall reach it in the coming years in spite of the possible price fluctuations which may take place in the world market.

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ANTHROPOMETRY AND ITS ROLE IN SOUTH AFRICA

BY

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Presidential Address to Section " D " of the South African Association for the Advancement of Science.

Delivered 2nd July, 1947.

During the preceding generation and hitherto, our physical anthropologists have devoted themselves intensively to unravelling the complexity of the extinct and living South African native peoples. "They have established, beyond doubt, some clues to the extensive amount of spade work which remains to be done before one can interpret completely the cultural aspects of South African anthropology" (Dart, 1929). Eager as we were in the past to demonstrate how large and how varied a number of racial elements had contributed to the composition of our ethnic groups there has been a dearth of investigation of the physical anthropology and the normal standards of physique of our adult European population, of the Coloured Races and of the Bantu. In a smaller degree this applies to children up to the age of puberty. It is this indifference in the past to obtaining the scientific data that would give us exact information of the physical structure, organisation and development of our white population, and the wide interest throughout the Union in the value of Physical Education and in the various problems connected with it, that have prompted me to choose Anthropometry for my Presidential Address to Section "D".

Since the latter half of the preceding century physical anthropologists have recognized that great racial problems cannot be solved by juggling with a few cephalic indices, that a human being is a vast congeries of faculties, that certain of these are highly correlated, that some are practically independent of the rest and that all are modified by intermixture in each new generation. They have found that it is wholly impossible to define an individual or a race or associated group of individuals, on the basis of a single character. They have realised that it requires a great many measurements to describe an individual with moderate accuracy and quite as many to characterise and provide the type of a local group of men. History compels me to mention here the name of Francis Galton, for it was he who pointed out first what may be achieved by this new method of approach to the study of race and racial characteristics. Karl Pearson (1924, p. 279) says of him: "They learnt for the first time to what extent characters are correlated

and how to measure the degree of their association. That could only result when the investigator learnt to deal with the whole system of variations and did not occupy himself simply with the averages of characters. The last quarter of the nineteenth century revolutionized anthropology and Galton was the main mover in those momentous changes."

In 1905, at the London Congress of the Royal Institute of Public Health, Galton gave an address on: " Anthropometry at Schools." In this address he defined anthropometry as follows: " Anthropometry, or the art of measuring the physical and mental faculties of human beings, enables a shorthand description of any individual to be given by recording the measurements of a small sample of his dimensions and qualities. These will sufficiently define his bodily proportions, his massiveness, strength, agility, keenness of sense, energy, health, intellectual capacity and mental character, and will substitute concise and exact numerical values for verbose and disputable estimates. . . . Anthropometry furnishes the readiest method of ascertaining whether a boy is developing normally or otherwise, and how far the average conditions of pupils at one institution differ from those at others. Though partially practised at every school—for example in all examinations—its powers are far from being generally understood, and its range is much too restricted. But as an interest in anthropometry has arisen and progressed during recent years, it is to be expected that the good sense of school authorities, assisted by the expert knowledge of medical men, anthropologists, and statisticians, will gradually introduce improvements in its methods and enlargement of its scope." (Karl Pearson, *loc cit.* p. 345.)

Great as Galton's achievements were in the realm of heredity and statistics, his one failing was that he tried to explain everything by the anthropometrical method. To-day Anthropometry (Somatometrie or *Körperbaulehre* of the Germans (Martin 1925)), is the method of finding an exact quantitative expression for the morphological characters of an individual by measurement and description of a fairly representative system of characters, and a discussion of the results obtained by such measurements.

In the first place anthropometry is a technical procedure. It has been perfected and elaborated by physical anthropologists for the purpose of studying different populations and races. Linear and projectional measurements, circumferences and angles are determined with reference to accurately defined points on the body surface or on the skeleton so as to make the work of different observers comparable. In this connection it is fitting to mention Rudolf Martin (1928), the Zurich and later Munich anthropologists who not only contributed more than any other to the standardization of anthropometrical technique, but also devised several measuring instruments which, with respect to accuracy and ease of manipulation, have not been surpassed.

In view of the fact that measurements are taken on the living subject and that many of them are projectional, it is self-evident that the body posture of the individual should be continually controlled by the observer. Without strict adherence to the standardised technique, data laboriously obtained are useless to the anthropologist. In a comprehensive report of measuring procedures and statistical analysis of data on 147,000 American boys and girls published by the United States Department of Agriculture (1944), the directions for measuring the body height run as follows: " the subject stands on the levelling platform, heels together against the wall. The buttocks just touch the wall. The eyes are directed forwards and the head is *erect*. The palms of the hands lie on the thighs."

One may here overlook the oversight that the individual be requested to stand erect, but that the head should merely be held " erect " and not in the " Frankfurter plane " means that the body height cannot with confidence be used for purposes of comparison.

It cannot be too strongly emphasized that reliable measurements can only be expected if observers use scientifically correct measuring instruments, scrupulously adhere to the prescribed technical procedure and acquire the necessary skill through practice and exercise. It is evident that students who follow a course in anthropometry must have a thorough knowledge of plastic anatomy and of the skeleton.

Data with respect to a character or group of characters have little value unless its distribution in a race or population are determined in accordance with the Normal Law of Probability. Anthropometry is therefore also a statistical procedure. Johannsen's dictum: "Wir müssen die Erblichkeit zwar *mit* Mathematik aber nicht *als* Mathematik treiben" (Johannsen, 1926), is equally true with respect to Anthropometry. Although the qualified worker in most cases relies upon a trained statistician to analyse his data, he must fully understand the meaning of such concepts as normal distribution, arithmetic mean, standard deviation, co-efficient of correlation, the fitting of a curve by the method of least squares, students' " t "-test, etc., otherwise most of the current literature containing an analysis of anthropometrical data will remain a closed book to him.

Historical.—Quetelet (1796-1874), Belgian astronomer, meteorologist and statistician is credited with coining the word anthropometry, and with making the first scientific study of physical growth. He was also the first to apply the statistical method to biological problems. In 1835 he published his principal work " *Sur l'homme et le développement des ses facultés,*" *un essai de physique sociale* (2nd ed. 1869), containing a résumé of his statistical researches on the development of the physical and intellectual qualities of man. and on the " average man " both physically and intellectually, His ideas were further developed in his: *l'Anthropometrie ou mesure des differentes facultes de l'homme.*

Francis Galton, the cousin of Charles Darwin, was the first to apply statistical methods to the study of biological problems other than those of anthropology. He was a born statistician. He was deeply interested in problems of biology, particularly those dealing with inheritance. In his work "*Natural Inheritance*" the attempt is made for the first time to determine on a statistical basis the degree of resemblance, in respect of bodily, mental and temperamental traits, which obtains between relations of different degrees. His "*Law of Ancestral Inheritance*", however, became untenable in view of the Mendelian Laws. In 1884 he founded in London, an Anthropometrical Laboratory with the sub-title: *For the Measurement in various ways of Human Form and Faculty.* In his Laboratory he showed the public the methods by which physical characters may be measured and recorded. Galton's Laboratory was the parent of Anthropometric Laboratories at Eton, Dublin and Cambridge; also of the much later work of Schuster. It was also in the eighties of last century that Dudley Allen Sargent began the systematic measurement of Harvard students. He made many anthropometric studies; was responsible for the introduction of anthropometry in the American Colleges, and developed new anthropometrical instruments. Towards the close of the century A. Bertillion (France) contributed substantially to the theory and practice of anthropometrical identification. In 1901 appeared: "*Du rôle de l'anthropometrie en education physique*" by P. Godin. In the interim 1910-14, the methods of measuring and items to be measured were standardised by an International Committee. In 1914 appeared the first edition of Rudolf Martin's: "Lêhrbuch der Anthropologie in systematischer Darstellung." To give a compilation in chronological order of the major events in the field of anthropometry from 1914 to the present day, would be wholly out of place. For a short History of Anthropometry the reader is referred to an article by Hyman Krakower (1937).

I next wish to refer briefly to the practical applications of the results of anthropometrical investigations apart from their usefulness in physical anthropology and ethnology. The anthropometrical method has been extensively and fruitfully applied in medicine, eugenics, social hygiene and physical education. In medicine it is of great value to the clinicist in diagnosing the constitutional types of Kretschmer, on the strength of their morphological characteristics (Borchardt, 1924; Fischer, 1924). This diagnosis will of course be supplemented by additional methods, dependent on a knowledge of the functional and psychological characteristics of such types. The question of the reaction of such constitutional types to functional disorders, has been very extensively investigated (Bauer, 1924). Jokl (1945) emphasized the fact that constitutional types have character equivalents which are revealed in athletics, gymnastics and sport. The recognition of constitutional types has also become of great importance in determining and defining racial characters. "If," says Eugen Fischer (1924), "we regard a constitution as something heritable—which in truth it is—and if it is of

frequent occurrence in a particular race, while absent in another, then it becomes in itself a racial character. Constitutional traits are also partly racial traits. But not everything constitutional is heritable. We are confronted then with the problem of distinguishing between what is heritable and what is acquired." (Transl. by the writer.) The solution of the problem depends largely on our knowledge of the distribution of constitutional traits in a population.

The social hygienist investigates what influence the environment, in its widest sense, has on social groups. Here anthropometry renders valuable assistance especially through the application of nutritional indices. By comparing the results of his observations with what has been found as the norm for each particular physical character or group of characters, the social hygienist is enabled to suggest what measures should be taken to eliminate or counteract any harmful influence on normal growth. Such investigations have been carried out on an extensive scale in Europe, particularly in Germany by Kaup, and in Russia by Erismann. Amongst others it has been found that the average body length of the youth in cities is greater than that of young men of the same age in the country. In the former, however, there has been a retardation in breadth of body in comparison with body length. The same applies respectively to individuals whose trade or occupation involves a maximum amount of muscular activity. Time does not permit me to mention the results of Lundborg's (1921) interesting researches in Sweden on racial admixture-results which have been obtained by the anthropometrical method.

In no other sphere, however, has anthropometry, been more fruitfully employed than in physical education.

Bach (1930) divides the anthropometrical measurements that are of fundamental importance into two groups.

1. Measurements of children: these include all measurements that are directly related to rate of growth. On the basis of such data systems of physical exercises are planned that will be conducive to the promotion of harmonious development.

2. Measurement of adults. These include measurements that will inform us with respect to such questions as: what changes can be observed in the physical characters and body proportions of men and women who take physical exercise regularly, when compared with those wo do not indulge in any form of exercise whatsoever ? What types of body build are best suited for different types of physical exercise? Is it possible to establish a definite relation between body proportions and types of physical performance? These and allied subjects have received repeated attention and the literature thereon is extensive.

The value of Somatoscopy to the teacher of Physical Education is liable to be overlooked. The study of the relation between the colour of the eyes, the skin and the hair primarily belongs to the

domain of physical anthropology. The determination of the nature and degree of pigmentation of the skin, has, however, important practical value for the teacher of physical education. It enables him to recognise the type of skin that is too sensitive to the direct rays of the sun. For children with such skins, it will be decidedly harmful to take part in exercises in bright sunlight with the upper part of the body exposed.

Anthropological Work Carried out on the European Population of South Africa.

Van der Westhuizen (1929) undertook an anthropometrical somatoscopic study on 128 Afrikaans-speaking students of the University of Stellenbosch. We may rightly look upon this investigation as a first contribution to the physical anthropology of our male European population. In his " Summary and Conclusions " (*loc. cit.*, p. 63) he says: " Certain of the results of this work are, if not important, at least highly interesting. I refer again to the tallness of the individuals which places them with the tall races of man. The meso-chamae-tapeinocephalic head form, the moderate broadness of the face and of the root of the nose which in itself is coupled with a relatively preponderant leptorrhiny, while the face in general seems to be of a leptoproscopic character are all extremely interesting features." Unfortunately a statistical analysis of the various measurements is not given. The number of students measured were of course far too small to determine the average height of age groups. Murray (1932) reported on the physique and nutritional status of the socio-economic group, generally known as the Poor Whites. His anthropometric observations were restricted to sitting height, circumference of chest and weight. In terms of these measurements he established a new index of nutrition which was found useful for the investigation as such. The sitting height is called length of trunk, and the girth of chest was not determined in accordance with the accepted definition thereof. The author (*loc. cit.*, p. 22) rightly deplores the fact that at that time (1931) there were no data available of the body measurements of the European child population of South Africa.

During the last ten years there has been a phenomenal development of physical education in South Africa. In 1936 a degree course in Physical Education was instituted at the University of Stellenbosch; Normal Colleges provided special courses, the South African Railways and Harbours and the Police showed a greater interest in physical exercises and completed their own scheme for instruction. A National Advisory Council for Physical Education was instituted to co-ordinate and promote physical education. Naturally this new phase in physical education gave an opportunity for the extensive and intensive application of anthropometry and anthropometrical technique, and the list of publications containing the results of investigations on the physique and growth phenomena

with respect to our European child population is already fairly extensive.

Brock and Latsky (1943) commenting on the grid constructed by Wetzel (1941) for development of height and weight in relation to age, stress the necessity for establishing a similar grid for South African conditions. Three years afterwards appeared the publication of a South African Grid for Height and Weight Growth of European School Children by Cluver *et. al.* (1945). Similar to Wetzel's grid for American children, it is a somatometric index derived from measurement of height and weight in relation to age. It is claimed by Wetzel that the seven channels in the grid present a range of physique from the obese to the very slender. The progress of healthy development continues in an established channel as though this were a preferred path. Channelwise progress indicates development with preservation of given physique, cross-channel progress is accompanied by a change in physique. For the construction of the South African Grid the height and weight of 1,514 boys and 2,035 girls were taken. It is not stated whether the boys and girls are from different geographical regions in South Africa, although the authors claim that it ".was constructed for purposes of use in this country" (*loc. cit.*, p. 19). Postma (1947) in collaboration with senior degree course students in Physical Education who have successfully completed a one year course in Anthropometry at the University of Stellenbosch, gives the following figures for a total of 1,926 boys and 2,184 girls between 6 and 18 years from various country districts of the Cape Province, the Orange Free State and the Transvaal—a majority being from the Cape Province.

BOYS.

	POSTMA.					S. African Standard Grid
Age	A.M.	n.	P.E.	Range	V.	
					%	
6	46·2	26	·449	3·40	2·89	46·0
7	46·6	102	·315	4·73	3·99	48·0
8	48·6	109	·360	5·68	4·55	50·0
9	51·4	116	·310	4·98	3·82	52·0
10	53·3	154	·280	5·30	3·91	54·0
11	55·3	177	·310	6·10	4·34	56·0
12	56·4	178	·330	5·97	4·18	58·0
13	58·9	181	·300	5·92	3·96	60·0
14	61·7	205	·370	7·78	4·96	62·3
15	64·0	230	·360	8·10	4·98	64·6
16	66·2	197	·380	7·98	4·75	—
17	67·4	157	·356	6·60	3·86	—
18	69·1	94	·340	4·90	2·79	—

GIRLS.

	POSTMA					S. African Standard Grid
Age	A.M.	n.	P.E.	Range	V.	
					%	
6	45·8	114	·272	4·31	3·70	—
7	47·9	169	·253	4·56	3·99	47·3
8	50·1	182	·276	5·52	4·34	48·9
9	52·1	195	·246	5·11	3·86	51·1
10	54·6	183	·301	6·02	4·33	53·6
11	56·7	208	·285	6·08	4·22	56·3
12	59·2	206	·322	6·87	4·53	58·7
13	61·3	231	·238	5·36	3·45	60·7
14	62·9	222	·250	5·52	3·45	62·2
15	63·6	216	·219	4·81	2·98	63·2
16	64·1	180	·244	4·85	2·98	—
17	64·5	78	·524	6·92	4·23	—

Comparing the body lengths of the age groups in the case of boys from the country with those given in the South African Standard Grid, we note that the latter are significantly taller. As has been pointed out above, the body length of children from the country in European countries is significantly less than, but the breadth of body, comparatively greater than that of children of the same age in large cities. Whatever other value the South African Standard Grid may have, the average heights given there are as yet not too useful for purposes of comparison for the simple reason that one does not know whether the children used for the construction of the Grid are representative of the child population. In spite of this, Cluver (1946) makes use of the South African Standard Grid for comparing the height of South African with that of English, American and Canadian children. It must be kept in mind that in 1945 the number of school children of each year of age from 6 to 15 was from 10,000 to 17,000 approximately, and that from 16 to 18 it was from 1,000 to 6,000 approximately in the Cape Province only (Dept. of Pub. Educ., Cape Prov., 1946). For the construction of the South African Grid a total of 1,514 boys and 2,035 girls was used.

In the field of race hygiene or eugenics anthropometry has been very effectively employed. Jokl *et al.* (1947) bring strong evidence to suggest that physical training can prove a very important factor in the biological rehabilitation of subnormal individuals. Anthropometric and physiological results are regarded as measurable equivalents of a profound and rather complex transformation which a training course had produced in the experimental subjects. The authors claim that "the physical education of every young citizen of the future will be regarded as a basic element in the evolution of a civilised society" (*loc. cit.*, p. 135). The value of physical training has become so much emphasized that a few remarks on its educational value will not be out of place. In the statement quoted above, the authors definitely attach a greater value to

organised physical training than some eugenicists are prepared to admit. Lenz (1923) for example, in no way denies or even minimises the value of physical education; but, he says, these benefits are primarily concerned with personal hygiene; that physical training improves physical efficiency is indisputable, but, from the point of view of the non-transmission of acquired characters, it is not possible to improve thereby the mental and intellectual capacities of the individual in like measure. Organised physical exercises are worthless as a factor in social selection which in its turn is founded on the important relation between education and eugenics. It is only the pseudo-eugenicists, he says, who profess that physical training is a sure panacea against racial deterioration. The standpoint taken up by educationalists generally, and by the protagonists of physical education in particular is that taken up amongst others by Kaupp. Although we cannot, he says, through physical education improve the physique of the individual beyond the limit fixed by his heredity, we must through education and environmental influences ensure that the sum total of his inherited *anlagen* will reach their maximum development. Every individual, he says, must, as it were first earn his genotype through proper physical development and healthy living, and so mould and preserve his phaenotype that the inherited *anlagen*, acquired anew, can be transmitted to the offspring with unabated quality and potentiality. We may here recall Goethe's words:

"Was du ererbt, von deinen Vätern hast,
Erwirb es, um es zu besitzen."

Anthropometrical measurements have also been used for establishing mathematical formulae or indices which are supposed to give information on the state of nutrition. Many such physical indices of nutrition have been proposed, but so far there is no agreement as to which index is the best. Latsky (1942) applied the A.V.H. and the Tuxford indices to children who had been classified by the Cape Nutrition Survey. He points out the limitations of both indices; neither of them could help him to discriminate between malnourished and diseased children. A high percentage of children whose examination and tests had shown them to be healthy and with satisfactory nutrition, were picked out by the indices as malnourished. In another publication Latsky (1944) expresses himself as follows with respect to somatometric indices: "they are obviously useless for the selection of malnourished children, and they probably depend on endocrine and hereditary factors which are under the control of influences other than just diet or state of nutrition. A typical example is the increase in skeletal stature and somatic growth as a result of endocrine influences at the stage of puberty, when anthropological factors may easily be confused with nutritional influences. In justification it can, however, be said that the indices helped to detect those individuals whose physical development was really below normal" (*loc. cit.*, p. 204).

In the foregoing I have attempted to indicate the importance and the practical application of anthropometry to physical anthro-

pology, race and hygiene (eugenics), medicine and physical education. At our Universities with their departments of Sociology, Ethnology and Physical Education, there are no organised courses in anthropometry and somatoscopy, much to the disadvantage of students who follow or wish to follow a degree course in which one or more of the above-mentioned sciences are major subjects. After they have graduated they will find that they will be unable to apply themselves to research in which a knowledge of anthropometry and anthropometrical technique is essential. I need not stress here the importance of anthropometry in the field of physical anthropology, a subject which has not yet won its rightful position in our Universities. At the University of Stellenbosch a full course in anthropometry including somatoscopy has been instituted since 1940 mainly owing to the advocacy of Prof. de Villiers. It is compulsory for students who take a degree course in Physical Education, and can only be taken after they have completed a course in anatomy and osteology. It is to be hoped that a course in anthropometry and somatoscopy will in due time be given in each of the newly instituted departments of Physical Education at the University of Pretoria, the University College of the Orange Free State, and at Rhodes University College. It is perhaps of interest to note that the writer has been carrying out measurements of students at the University of Stellenbosch since 1941, with the object of obtaining correct physical anthropological data with respect to university students of from 16 to 26 years of age.

When we look ahead, leaving physical education with its own problems out of account, we are practically just on the threshold of research with respect to the physical anthropology of our white population. There is first of all the question of establishing a correct average of the different body proportions. We must ascertain how far these proportions differ in the various geographical regions of South Africa. Then there is the question of isolated communities. In the Cape Province we have at least three such communities: a Namaqualand community, one occupying a small mountainous area near Prince Albert, and the Knysna Bush community. In the Transvaal we have the people occupying the malaria-stricken region.

In the future, even more so than in the past, anthropometry will contribute to the enrichment and proper development of any type of genuine sport that is founded on a scientific basis. When it is a matter of continuous registration of the physical status of adult sportsmen, only a few measurements will be required. Its usefulness is, however, capable of extension: a more comprehensive group of measurements is required in cases where it can contribute to the solution of problems in which a particular type of physical performance is intimately bound up with anthropology and with biology in general.

Anthropology with its handmaids, anthropometry and somatoscopy, has not reached its goal. It cannot rest on its laurels. It remains in a state of flux. It covers a field that enlists the interest

of everybody. Some inquire into the inheritance of certain characters and constitutions as revealed in family histories; others into the hereditary *anlagen*, characteristic of the race and the distribution therein of constitutional types and it is in this connection that laborious investigations into the physique of the child population and of the student communities at our Universities acquire greater importance. Others again are investigating problems in eugenics. The sum total of the results obtained from such researches would provide us with that knowledge of the heredity, composition, physique and potentialities of the diverse races in the Union which is so essential to the framing of policies for the preservation and development of the most valuable genetic types of the population and for the maintenance of peaceful relations between the ethnic groups in South Africa.

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ANCIENT RAISED BEACHES AND PREHISTORIC CIVILISATIONS IN SOUTH AFRICA.

BY

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Presidential Address to Section "E" of the South African Association for the Advancement of Science.

Read July 2nd 1947.

For some fifteen months before I landed in South Africa in 1942 I had been studying the western Portuguese coast in its relation to the local prehistoric industries, with the geologist, G. Zbyszewski. I had also been to Morocco to see the old beaches of Abderrahman (Casablanca) where Messrs. Neuville and Rühlmann found the Sicilian, Milazzian and Tyrrhenian beaches in superposition, characterized by shells and containing, or bearing in interpolated exposed deposits, Abbevillean and Acheulean bi-faced industries, and others with Tayacian flakes (1).

I wished to apply the knowledge thus acquired to a study of the South African coast, of which I had seen something in 1929, at Mossel Bay, Still Bay, Knysna and the Cape Peninsula.

Dr. A. V. Krige had written a remarkable geological work on raised-beaches, but was not concerned with archaeology (2). Others had studied terraced deposits near the mouth of the Orange River; but paid more attention to diamonds than to Middle Stone Age tools (of which I saw a big collection in 1932 near Frankfurt, Germany) collected previously by German engineers.

War conditions were unfavourable to such research and, though I obtained authority for such work several times, I could not obtain the detailed maps necessary. I have already partially described (3) the very imperfect results obtained at various points, during February and March, 1943, October and November, 1944, and February, 1945. Briefly, in the Cape Peninsula and its neighbourhood I found Old Stellenbosch (Abbevillian) waterworn in a 320 ft. beach at Simonstown, and Middle Stellenbosch unwaterworn at 140 ft. and above. The mid-Stellenbosch site of Cape Point, unwaterworn, spreads out above the height of 300 ft. At Fish Hoek, unwaterworn Upper Stellenbosch bi-faced tools came from a level of 70 ft. At Pollsmoor, the beach between 200 and 300 ft. contains Mid-(?)Stellenbosch tools unwaterworn, and others far older and waterworn.

The Eerste River Valley (which I studied with particular care with Dr. and Mrs. E. A. Nobbs both before and since my last note(3)), revealed a very low-level gravel, some 10 ft. above the river at Spier Farm (100 ft. O.D.), containing very waterworn Mid- and fresh

Upper Stellenbosch on this surface. But on the neighbouring farm, Olives, facing Spier, and also at Lynedoch, on a wide marine platform, the oldest Stellenbosch, both waterworn and unwaterworn, is found on a level of kaolin soil from 360-400 ft. The unwaterworn Mid-Stellenbosch goes down as low as 220 ft. O.D. (these observations were made by Dr. Nobbs). Approaching Stellenbosch, the plain rises and these high levels keep their altitude approximately and finally blend with the very old gravels on the golf course, crossing intervening sites, where recent gravels cover and dip into them (Box Factory).

An excursion made with Mr. F. Malan to Cape Hangklip and Pringle Bay showed me extensive workships of final Stellenbosch superposed on the 60-80 ft. beach. At Cape Hangklip the beach pebbles contain older waterworn specimens.

To return to Mossel Bay, the altitude of the Upper Marine Gravels, from which same two pieces discovered by me in 1929, near the reservoir on the old golf course, is (according to the more recent maps), about 260 ft. The surface site on the old golf course stand a little higher.

I think it would to-day be useful to separate from my other notes on the subject my observations on:—

(1) the neighbourhood of Hermanus;

(2) that of Riversdale;

(3) that of Buffelsjagts near Swellendam;

all of which confirm the fine discovery (4) of the geologist Mortelmans at Keurbooms, Plettenberg near Knysna, of waterworn Old Stellenbosch bi-faced tools in a marine level of about 400 ft.

1. Excursion to Hermanus.

I wished to see if the conditions described in my earlier note on the Eerste River and Cape Peninsula were repeated between Cape Hangklip and the coastal region, stretching to Still Bay and Knysna. To do this, Professor van Riet Lowe organised a very brief excursion during February 1945. I think the results sufficiently interesting to merit description.

Coming down from Elgin and Grabouw towards Hawston on the coast, we followed the course of the Bot River without stopping; a spit forms a ba rier near the sea, which (as in many other places on this Southern coast), has turned the lower river into a lagoon. In several places along the valley, gravel deposits often exposed by extraction are piled up to different heights. A narrow passage between the mountains and the sea leads to Hermanus, a town built on a fairly wide flat shelf cut by the sea in the quartzitic sandstone, 50 ft. O.D. at the shore, but slowly rising to about 90 ft. where rocky boulders and a conical knoll (Klip Kop) probably mark the limit of this raised-beach.

I carefully examined this beach south of the east side of the town. The rock there is sparsely and discontinuously covered by a thin cloak of not very old blown sand. Where the rock outcrops,

scattered quartzitic pebbles and derived flakes occur in the surface. The flakes belong mostly to the Middle Stone Age (probably the older part of it), and are wind-worn but not waterworn, except for a few flakes and the base of a small bi-faced tool. The latter are wave-worn and seem to belong to the final Stellenbosch industry, so plentiful at Cape Hangklip. Klip Kop is 255 ft. high and is wave-cut on the seaward side, to form a cave at 130 ft. O.D. This knoll has no paintings, but remains of kitchen middens spread widely over all the slopes. These middens contain a number of chipped pebbles and many atypical Late Stone Age flakes—certainly not very old.

Looking towards the slopes of the neighbouring mountains (2,500 ft. O.D.) and behind the projecting rocks mentioned, a second platform can be seen, covered with brushwood and bushes. This runs up to two quarries of yellow sand mixed with gravel (standing fairly high, more than 250 ft.) used for the roads, gardens and public paths of Hermanus. I do not know if these contain an industry, since there was not enough time to explore them.

Our principal investigations lay to the east, near the road to Stanford and Caledon. This crosses the Mossel River a short distance from Hermanus. The ground below it is very much lower than the flat on which H rmanus stands; another terrace is found on the upper side of the road, running beside it some distance, and bordering the whole length of the lagoon at about 80 ft. O.D. Behind the flat ground lying between the road and the mountain, two higher terraces are seen. The lower (though cut through by erosion), still partially preserves its flat surface; the higher is nothing but a series of projecting hillocks, the result of intense dissection. The lower level, which the road follows, has a few little quarries for extraction of materials for the upkeep of the road. The labourers leave the pebbles, shipped or not, strewn about the ground, but use the conglomerate of ferricrete or calcrete granules.

In one of these quarries, a little before Silvermine, the pebble beach (rather shallow, not ironstained, and not of very coarse material) yielded a rather important series of upper Stellenbosch, unweathered and very lightly patinated, like the industry at Hangklip. It is about 80 ft. above sea level.

Farther on, I think, the road climbs to the middle level (100 ft. O.D.) and, facing Stanford, before crossing the valley, the soil is rather ironstained and contains old worn and browned Stellenbosch; Middle unworn Stellenbosch with ridges a little blunted and clear yellow in colour, as well as a little Upper Stellenbosch, whitish, but with no proper patina.

On a site intermediate between these two, between the road and the *thalweg*, or the head of the lagoon (probably at a height of 80 ft. O.D.), there is a quarry with many large boulders, highly polished and showing signs of very heavy blows all over, which seem to me the result of wave action. They are sunk in yellow sand and a good many chipped specimens of, I think, Middle Stellenbosch, with a light yellow patina can be found, not at all waterworn.

Stanford is built on a wide terrace (95 ft. O.D.) of ironstained pebbles which we did not explore, but, on the Church square itself, several pieces of Middle Stellenbosch, moderately ironstained, lay amongst the stones on the highway.

Another indication of the successive fall and rise of the continent during later geological times, is the carving of the northern slopes by water. The lower half of these slopes, below the sandstone of the Table Mountain system, consists of a cliff of granite, almost completely denuded and very rounded; the ravines running downwards from gorges at different levels, have not deepened much since they were first raised above the low country; only insignificant cuttings score their rounded contours.

One of our aims was to find a spot, where fossil mammal bones had been found at various times. Many places have produced them, and the specimens kept in the Stanford School by Mr. H. H. Smuts, the enthusiastic school principal, came from two places in the neighbourhood. These include the humerus of a very big elephant, in perfect condition; two molars of an African elephant; a milk tooth of the same species, but more fossilised; a fragment of a rhinoceros' upper back molar; the jaw of a hyena, and some small remains of buck and zebra, and of the Cape lion.

The southern rim of the basin, at least 400 ft. O.D., is covered with consolidated sandy eolian formations, piled on each other and of successive ages. The stone of which the pretty church is built is *lumachelle*, a sandy limestone containing many small shell fragments; the quarry whence it comes can be seen on the projecting slope dominating the village.

The site was further upstream. It is reached by leaving the Caledon road just after Stanford, and taking a farm road which climbs towards an upper terrace of 500 ft. O.D., covered below the arable soil by a very ancient and hard ferricrete containing bulky pebbles and chipped stones. The Old Stellenbosch specimens are very dark in colour and, though not waterworn, much windworn. The Middle Stellenbosch examples, sometimes embedded in the breccia, are only yellowed, and have moderately sharp angles. A recent Stellenbosch specimen has hardly any patina and does not come from the ferricrete.

We are here on a 500 ft. terrace—therefore higher than the level at which the Old Stellenbosch could be waterworn. The small farm Nooitgedacht, is slightly lower, in a little valley hollowed by erosion in this same level terrace.

In search of the site producing the bones, we went on for 2 or 3 miles and reached the small farm Windheuvel, near one of the bone-bearing sites. A fairly deep ravine with a permanent stream starts quite near the farm, cutting a deep furrow through consolidated dune; the hardness of the dune-sand varies, forming perpendicular ridges and shallow shelters overlooking the slopes; rather dense brushwood covers them and the floor of the valley. The ridge runs approximately north-east-south-west—towards

the bay which is the mouth of this Little Brak River. All this outstanding ridge seems to be a vast mass of consolidated dunes of different ages, piled one on the other. The site near Windheuvel is at a dominating point forming a sort of headland on the right bank of the ravine. The rather compact rock which forms the nucleus, and contains some beige-coloured bones, was, at a fairly late Quaternary epoch, deeply corroded by wind action which hollowed out the shelters, later completely hidden by fresh imperfectly consolidated blown sand of fairly recent date, containing many bones. These are not broken by man, but suggest the remains of the meals of big carnivores, lions and hyenas, remains of which have been collected, as well as teeth and long unsplit bones of small buck and equids. Porcupines first, then modern man, excavated these shelters deeply, where I was told Péringuey and others collected many bones. The headland and its neighbourhood were occupied by Late Stone Age Man; small chipped quartz flakes are plentiful, and a small pebble used as a grinder was picked up amongst the debris left by the excavators.

The roof of the caves is formed by horizontally stratified sandbeds, including certain levels of very pure sand containing diatoms, a specimen of which was sent for examination. Its very light specific gravity led me to think it a diatomite formation or "fossil flour", of which there is a sample in the Stanford School.

It is probable that there were scattered marshes or ponds in the depression between the dunes before the action of the stream dug out the ravine, and before the modern valley-topography was established.

All this ridge of consolidated dune is worth more careful examination. It seems to me to be somewhat like that which Mr. T. J. D. Fair* described when writing about comparable phenomena on the Natal coast, where they seem far more spectacular.

* T. J. Fair: Pleistocene and Recent Strand Movements in Southern Natal, *Transactions, Geol. Soc. of S. Afr.* No. 19. (Geological Department, Natal University College) Vol. XLVI, 1943. He says that "before the two rises established by Krige, first of 40-100 ft. and then from 15-20 ft., the coast line had risen as a coastal plain about 500 ft., sinking later to 150-200 ft. The covering dune is bordered by a ridge of red sand at 200 ft. O.D. The spurs of dune closing the valley mouths date only from the time of the 20 ft. rise."

A little before rejoining the Caledon road on returning from Stanford, Prof. van Riet Lowe noticed a donga eroding the slope on the left, more or less south-west of the road. He went upstream and discovered a wide denuded surface covered with a Later Stone Age industry, including chipped quartzitic pebbles recalling the Middens, abundant, very well worked silcrete material, with numerous blades and bladelets, microlithic crescents, and many small thumbnail scrapers and even a piece of a pierced stone ball. Erosion had encroached on the upper level of a granulated ferricrete, and Middle Stone Age material was mixed with that mentioned above.

In the ravine I noticed an interesting section; the bottom showed more or less conglomerated sub-angular grit containing a half-made Late Stellenbosch tool. Above this came a first sandy level, rather highly coloured, ending in a calcrete level. A second sandy level overlay this, analogous with the first, and crowned by the granulated ferricrete mentioned above. Where erosion had cut away the calcrete to form a platform, silcrete blades and triangular flakes, with prepared striking-platforms of the Middle Stone Age, are seen on this surface, having come down from the superposed deposits.

On the way back from Stanford to Caledon (passing through Elgin and so to Stellenbosch), we went up the valley of the Klein River, stopping three times to examine gravels in its course between high banks, where it breaks through the mountain barrier. First we visited a small borrow-pit slightly lower than the rocky slope. The ironstained gravels carry Middle Stellenbosch, unwaterworn but ironstained. As one of the tools of this age is made of a flake struck from a chipped, waterworn and older specimen, the gravel certainly contained more ancient examples.

A little higher, between 400 ft. and 500 ft. the valley is partly closed by a sort of " shutter " of granite on the left bank, against which (downstream only) a considerable mass of gravel has been piled by waves coming from downstream. The same formation is not found on the upstream side of the " shutter ". Here we find what are pebbles probably from some beach, at a level higher than 400 ft.

Further upstream, at a point where a side-road joins the main one, and more or less 100 ft. above the river, there is a wide quarry of very ironstained analogous gravels (about 500 ft. O.D.) very rich in Stellenbosch of various ages. The oldest are much ironstained and worn, but not waterworn (Stellenbosch I); the rest are yellow and have fairly sharp arrisses like those of Middle Stellenbosch. The presence of these gravels is not explained by saying they were brought from upstream, for, from this point, the upstream river flows through a country with no quartzite, going downwards from the wide, raised basin of Caledon. We must therefore imagine (as with the preceding site), that something brought them from downstream; that is to say, we must admit that at a time when the sea-level was at about 500 ft., the valley of the Klein River was a fjord, where the waves brought pebbles, and lower down, wave-action spread them out in more or less horizontal shelves. It is only below about the 400 ft. level that Stellenbosch I is definitely waterworn.

The wide Caledon basin contains no pebbles from this point as far as the town, as it is formed of Malmesbury shale cut up into deep valleys, in spite of its surface-plateau appearance. Between Caledon and Grabouw there is a change. Only on the tops of the crests do we see the remains of coarse gravels, fairly old, no doubt Tertiary—all that is left of a deeply ironstained sheet of gravel which once spread all over. Enclosed within this wide sea basin

(which communicated to the east by straits with the more open sea, as it did also to the south-west), in the latter direction, in the smaller basin of Grabouw we may see remains of a stage when the Tertiary sea was in retreat. From here the successive levels of ironstained gravels descend in steps (as we saw when coming down to Hawston by the valley of the Bot River), evidence of fluvial or fluvio-marine action, much the same as that which we saw along the Klein River.

II. The Neighbourhood of Riversdale.

During 1929, I was received at Riversdale by Dr. C. H. T. D. Heese, and several days were devoted to an examination of his considerable collection and to visiting the Cave of Hands and Still Bay. We had no time to study the gravel beds of the district which had yielded a number of very primitive and massive tools to our host. These obviously belonged to very ancient ironstained gravels. Dr. Heese generously gave them to Mr. Harper Kelley and myself, and they are now in Paris. From the very high Cave of Hands, he pointed down to the hill tops from which the ancient material came. On returning to South Africa I was anxious to revisit these sites, and, thanks to the friendly hospitality of Dr. Heese, was able to do so in November 1944, though (as always in this immense country, so rich in ancient remains), far too rapidly. Thanks to Mr. J. P. Marais we were able to drive about the country. The following notes give the results of these various excursions.

A. At *Ligtenbos* on the road to Albertinia (barometric altitude about 620 ft. O.D.), the edge of a plateau slopes steeply to the south towards the sea, which is too far away to be seen. Here there is a fairly large quarry from which ferricrete, very coarse sand, and calcite conglomerate are taken for the roads. The sub-soil contains kaolin, and has coloured a rather shallow deposit of beach pebbles which lies on top. Above (with more derived pebbles), there is ferricrete which has coloured these pebbles brown or dark mahogany. Amongst the quarry debris there are a good many Stellenbosch specimens, which are only yellow (if they belong to Middle or Upper Stellenbosch), but others are very dark in colour and mere primitive pebble implements; they belong to the oldest stage, and, although very worn, do not seem to be waterworn. Man of that early period must have settled on the beach, very shortly after the retreat of the sea. This is not a river deposit in a valley, since the opposite slope did not exist.

B. *Soetmelks River Height.*—At the junction of the old road and the modern national road there is a flat surface at a height of 480 ft. O.D.; the river, which finally encroached on it, runs at 340 ft. This site is immediately below site A. and is also a marine flat, covered with ironstained pebbles. There are thousands of chipped Middle Stellenbosch flakes, etc.—not waterworn, and therefore later than the sea-beach. Some few bulky Old Stellenbosch specimens, worn by the waves, are also found there. This level is

therefore later than Old Stellenbosch times, but earlier than Middle Stellenbosch days.

C. *Kaffir Kuils River Bridge.*—Going to Riversdale by the national road, heights comparable to those of the first site are crossed, and the road section shows that the gravels are conglomerated in ferricrete which has a very hard surface; they rest on other gravels, whitish in colour, forming in certain places real pockets in the kaolin or sandy kaolin. We did not find anything derived from this white gravel bed.

After the bridge on the Kaffir Kuils River, the road to Riversdale climbs a steep slope which cuts through a thick gravel bed; the lower gravels are mixed with kaolin, showing white pebbles tinted with rose. Here I found a few chipped pieces *in situ*, morphologically atypical. Higher up, the same gravels became ironstained, and also contained coloured stones. Above this came sand-clay deposits coloured by ironstain; in the midst of these there is a grit level. The altitude seems to me not very different from Site B. (480 ft. O.D.), but more research is needed before the industrial level can be archæologically defined.

D. *Bridge near Dassie Valley* on the national road. The site (a short distance from Riversdale near the bridge of Dassie Valley) is some yards to the right of the road at the foot of the slope of a koppie. A small quarry has been opened, not in the gravel *in situ*, but in a rubble of pebbles descending from above to the foot of the slope. Stellenbosch of different ages can be picked up. The heights were taken with the barometer, taking Riversdale Station as zero at 400 ft. O.D.

E. *Brakfontein Farm.*—Descending towards the ocean by steps, each one immensely wide, and corresponding no doubt to ancient beaches masked by sub-aerian deposits (probably ancient dunes), we arrive at Brakfontein farm. This is situated in a cleft on the lowest of the plateaux, at a height of about 80 ft. O.D., as Dr. Heese told me. Here we see the ironstained gravels, cut through by the road or disturbed by ploughing. They may correspond to a Tyrrhenian beach. Underneath the valley-dune, where the wind has blown it away, the Middle Stone Age, Wilton and different variants of the Later Stone Age are found in profusion, as they are on the gravel terrace overlooking the farm. But various series of evolved Stellenbosch, not waterworn, and coloured yellow, are also found on the gravel terrace. They are similar to the series in the ironstained sands which immediately overlooks the present shore from a height. This is the third level of sea gravels, piled up between Riversdale and the ocean, and on the surface (as at Hangklip) is a rather small-sized late Stellenbosch.

III. Buffelsjagts.

Thanks to Mr. Marais I was able to make the hundred mile trip from Riversdale to Robertson, followed by one of 25 miles from Robertson to Worcester.

On leaving Riversdale one very soon rises above the level of the ancient beaches, and (except at Heidelberg at the crossing of the river where there are small banks of little pebbles), the neighbourhood of Buffeljagts River about 45 miles from Riversdale, must be reached before a waterworn stone is seen. Just before crossing the Buffelsjagts River, the national road cuts deeply into a thick gravel deposit, the highest point of which, according to the barometer, is 415 feet and the lowest edge 394 ft. It is about a mile higher up the valley that in 1929 the Rev. A. W. Sharples showed me a quarry excessively rich in very old Stellenbosch, with some implements of more recent date.

The national road from Port Elizabeth to Cape Town crosses the Buffelsjagts River about two miles to the east of that locality and of Zuurbrak. The gravels mostly lie on the left bank, in various terraces extending for one or two miles upstream. They are found less well preserved on the right bank. I was able to examine the region more thoroughly than in 1929.

On the steep slope towards the left bank of the river, there is a wide untouched section of coarse gravel, between 415 ft. O.D. and 394 ft. O.D.; the river flows at 254 ft. Another symmetrical section lies on the right bank above the bridge. A series of quarries for the extraction of road material extends for more than a mile along the left bank. Only the first belongs to the upper terrace, like the two sections on the road.

Another fairly large quarry slightly further upstream, is on a middle terrace on the old road at a height of 334 ft. O.D., or more or less 80 ft. above the river. Upstream on the left bank, the upper level rises rapidly; a quarry on the upper terrace is at the same height, but the chief one on the middle level is at the maximum height mentioned (335 ft. O.D.). Upstream, after a stretch where the extractions for road building cut into the shale, the other small quarries seem to me cut into alluvial rubble, mixed with angular grit and pebbles from the upper level.

I. Gravels of the Upper Level.

A. *Left Bank.*—The section of the national road shows a ridge running parallel to the valley and about a hundred yards wide. The deposit peters out at the two ends. It is composed of the following levels from the bottom up, which rests on a sandy white clay with kaolin staining of a rose colour.

(1) Very waterworn coarse gravel (white stained with rose), penetrating into the lowest deposit at the base, which partly assimilates it; several chipped pieces come from here and were found *in situ*; one is from the very bottom. There are a few flakes and some chipped facetted pebbles, worked from the ends or along the edges, their shape is not very typical. They seem to be abandoned half-made pieces.

(2) Very waterworn big pebbles, iron-tinted; the upper undisturbed part of the above level. The stones are oxidised and several similar implements have been found *in situ*.

(3) Very ironstained rubble, with small pebbles, not conglomerated, containing a good many chipped flakes and unwaterworn instruments of Mid-Stellenbosch type.

B. *A quarry upstream on the left bank.*—Though the rather limited sections are in a bad state, it is evident that they are similar to those described already. Amongst the material extracted are fragments and big cores belonging to the same ground, and certainly chipped by Man.

C. *Section from the national road to the right bank.*—The road cuts through the extreme edge of the formation upstream so that the section (about 100 metres long) is one-sided, the soil sloping towards the north. The beds are the same, except that, between the coarse gravel and the rubble, there is a fairly thick deposit of yellowish stratified sand. This partially protected the upper basal coarse gravels from being coloured red. Several very waterworn specimens were found *in situ*; the material removed when the road was cut produced a great many very waterworn chipped white stones, far better and more typical than at the two other sites. There were heavy prepared cores with big flaking on all faces; large or smaller flakes, very roughly worked elongated sub-prismatic implements which may have served as picks; oval flakes retrimmed into very coarse bifacial ovate tools. The higher rubble contained typical Middle Stellenbosch tools, reddened by contact with the ironstained upper level.

2. Gravels from the Middle-Level Quarries.

A. A single fairly extensive quarry has been opened. This is the one to which the Rev. Sharples guided me in 1929 when I collected a great harvest. It exposes a much wider area now, climbing a rather steep slope; it is only at the top of this slope that one realises that there is a very definite flat terrace lower down at 335 ft. Material seems to have been carried there later as grit from the higher level.

Chipped stones, waterworn in varying degrees, are numerous in this resorted gravel, which is lighter in colour towards the bottom, and finer towards the top where the Middle Stellenbosch is found, light coloured and not waterworn.

Beds of coarser gravel, lying lower down, contain only tools and flakes, waterworn in varying degrees, belonging to the two first Stellenbosch sub-divisions; the older with many very rough much waterworn types, the later finer, less waterworn and more regular.

The lower terrace, where there are no quarries nor any section where observations can be made, has not been examined.

When comparing the series of gravels in the Upper and Middle Terraces, it should be noted that (except for a small number of pieces derived from the first, and lying in the second terrace), the specimens differ. Those in the oldest gravel are far more waterworn. Thus it is likely that if, by further transport, they had been introduced into the second gravel, they would have ceased to be

recognisable. If they were derived from an early gravel, they must therefore have been fresh pieces or very slightly worn. In addition, even the shapes differ and, in spite of the indisputable archaic character of the majority, many of them have a less uncertain technique, as if the worker was more sure of himself.

IV. Conclusions Based on the Facts Observed.

From Riversdale to Zuurbrak, the plateaux are continuous and (at least as far as Swellendam, from the left or north-east side of a gulf, very wide at its starting point and flowing from Cape Infanta to Cape St. Blaize) they are silted up with sand, and blocked nowadays by dunes; they then grow far narrower and become a sort of fjord. The gravelly formations of Riversdale (of which the highest rest on a soil containing kaolin), are the same as those found at Buffelsjagts. As Dr. A. L. du Toit pointed out to me, both have covered an ancient peneplain, which lay at an approximate level of about 400 ft. After these phenomena, the rivers cut rather deeply into these deposits, disturbing the material. But at Buffelsjagts the kaolin gravels of the high level contain many remains of the oldest Stellenbosch industry, worn by the sea on the beach. From this point of view, it is the most important locality, confirming my observations on the Cape and Stellenbosch regions as set out in my previous note.

The importance of these facts is considerable, since it is difficult to correlate the terraces of the Vaal with the same type of deposits in Europe and North Africa. It seems much easier to find a satisfactory link by comparing coastal levels.

In Portugal, Mr. Zbyszewski and I proved :

1. In the extreme projected end of the raised-beaches, lying at 90 metres (300 ft.) O.D. (Sicilian), there were Abbevillean tools and many pebble implements.

2. We have found nearly nothing in the sandy beaches at 60 m. (200 ft.) (Milazzian).

3. The 25–30 metre (80–100 ft.) level (Tyrrhenian) contained Acheulian material.

4. The Grimaldian or Monastirian level, at 12–15 metres (37–47 ft.), only contained the late Languedocian, Ancorian, Mousteroid and Mousterian industries which linger on during the Würmian fall in sea level.

Slightly earlier at Casablanca (Morocco) Messrs. R. Neuville and A. Rühlmann discovered a complex of interlocked beaches; the oldest (the Sicilian), rises as high as 90 metres (300 ft.) and contains (only at about 29 metres (90 ft.)), some waterworn pebble implements, and two poor handaxes comparable to those of the 100 ft. terrace of the Vaal at Vereeniging; at the same site (Abderrahman quarry) a Clacto-Abbevillean industry overlaps the beach gravels—identical with that of the 50 ft. terrace of Vereeniging.

In the sub-aerian superposed levels, which are far earlier than the Milazzian beach, a level with small flakes appears, underlying the first consolidated dune. A second such level is superposed on the Milazzian beach pebbles, rising as high as 60 metres (200 ft.), and is in turn covered by a thick consolidated dune. This happened before the waves of the Tyrrhenian Sea rose as high as 30 metres (100 ft.) to cut caves in this dune cliff, and pile up Neo-Abbevillean waterworn gravels in them.

When the Tyrrhenian Sea sank, these caves were freed and Acheulian people visited them. There were many more at El Hanck (in the quarry Martin) where the Tyrrhenian beach contains waterworn Abbevillean. The Acheulians exploited the exposed gravels of this beach, leaving many instruments on the surface and introducing some unwaterworn into the mass, during their extractions.

The Acheulians continued to live there, developing their industry whilst dune and other sub-aerian deposits were laid down on the 30 metre beach. As for the low Grimaldian or Monastirian beach, everyone agrees that it should be classed as local Levalloiso-Mousterian, continuing during the Würmian drop in sea level.

In South Africa also, the Tyrrhenian beach exists between the 40 and 80 ft. levels of Cape Hangklip, covered with recent unwaterworn late Stellenbosch. The lower 20 ft. beach at Mossel Bay has amongst its pebbles a rather roughly made industry, samples of which I saw in the S.A. Museum at Cape Town. This belongs to the dawn of the Middle Stone Age, underlying a later facies which is still archaic. Mr. D. R. Macfarlane found this Middle Stone Age in the beach at East London, where it must have lain at the time of the Würmian fall in sea level, an epoch when a marked pluvial period plastered the bone-bearing breccias of the more evolved Middle Stone Age rock shelters of Makapan in the northern Transvaal with stalagmite.

Turning to the southern coast of South Africa, an examination of the map (combined with the facts already noted near Mossel Bay and Knysna), suggests that at the dawn of the old Paleaolithic, that region was cut into by deep bays, now silted up, where older Stellenbosch man chipped big tools (4) on a shoreline near the present 400 ft. O.D. These bays silted up during the development of the Upper Stellenbosch, and spurs of dune formed a barrage, turning them into lagoons at the dawn of the Middle Stone Age. See footnote "T. J. Fair, p. 65."

I did not have sufficient time to verify whether the south-east coast (which, at first sight looks very different), presents the same or analogous phenomena. The 400 ft. O.D. raised beach mentioned by T. J. D. Fair makes it seem likely.

The verifications or discoveries we were able to make in 1944 (thanks to a tour in Southern Mozambique, made possible by an invitation from the Portuguese authorities), point the same way. We saw unwaterworn Middle and Upper Stellenbosch strewn on the top of the cliff at Magude at an altitude of about 60 m. O.D.

and 40 kilometres (25 miles) from the present coast. We discovered a huge workshop of Old Stellenbosch on the highest felsitic plateaux on the road to Moamba ; both finds fit in very well with our southern results (5).

As for the western coast, details have been communicated to me which confirm its wide submersion during a Quaternary geological epoch. Dr. A. L. du Toit told me that, in a recent boring in the hinterland far behind Saldanha Bay, a bed of Quaternary marine shells was discovered. Dr. Nobbs, on the other hand, told me of projecting rocks with phosphatic deposits on what is now the 50 ft. O.D. level, running parallel to the coast in the vicinity of Darling and Vredenburg (north and south of Saldanha Bay). These could be very well accounted for if they were considered as ancient islands frequented by sea birds, in the days when the sea still covered the rather low-lying regions, as are Dassen and Robben Islands to-day.

An examination of the coastline shows us an evolution in Palaeolithic civilisation developing along the very same lines as in Portugal and Morocco, in the midst of several transgressive and regressive contemporary movements, and exhibiting fairly similar industrial stages.

The key to the synchronization of the South African civilisation with that of the Old World lies in a comparison of the tool-containing beaches. Not only is there no reason for reducing the age of the Palæolithic civilisation in South Africa, but the great development of pebble and early flake cultures in the ancient Vaal Gravels, at other sites in the Union and the rest of South and tropical Africa, combined with the discovery of Anthropoids with a human tendency in the Pliocene (and not the Quaternary as has been first stated), may lead one to think that in Africa primitive humanity, or one branch of it, started very early on the conquest of the world, armed with a stone.

It seemed likely that analogous facts would be found in South Africa, and this I think I have proved, so far as means and time have permitted. It may perhaps be said that as regards the beaches, those I cite have no shells; but although that may be said of many present-day beaches, the preservation of shells in ancient sea levels, as everyone knows, is subject to chemical contingencies. Shells are only present in very rare circumstances, all the rarer as we deal with still older beaches. In Portugal we found only a very small number of such places with shells. On the other hand, I know that it is difficult, in very ancient levels, to affirm whether the gravel beds come from the ocean or (if at a short distance from the shore), from a stream flowing into it. Even if the second hypothesis seems to be the most likely, since we are dealing with stream deposits in direct relation with the sea, these deposits instruct us on the ocean level with sufficient precision to give the correlation which I think I have established.

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POSTSCRIPT: In the course of a journey in June, 1947, Prof. Van Riet Lowe and I noted the presence of old waterworn Stellenbosch in raised marine terraces rising to an altitude of 250 ft. at various sites along the coast of Natal. (Van Riet Lowe, C.: "A Brief Account of an Archaeological Reconnaissance of Natal". *S.A. Archaeol. Soc. Bull.* Vol. 11, No. 7, 1947, pp. 68-78.)

South African Journal of Science, *Vol. XLIV*,
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THE DEVELOPMENT OF CENTRAL AND SOUTHERN AFRICA; SUGGESTIONS FOR RESEARCH AND ACTION ON SOME OF THE PROBLEMS COMMON TO THESE TERRITORIES.

BY

J. D. Rheinallt Jones.

Presidential Address to Section "F" of the South African Association for the Advancement of Science.

Read 3rd July, 1947.

Abridged.

The need for Study and Collaboration.

In closing his memorable survey of Africa, Lord Hailey says :

> "We see before us now the most formative period of African history, and much that is done to-day will have a decisive effect on the African people. The task of guiding the social and material development of Africa gives rise to problems which cannot be solved by routine knowledge; they require a special knowledge which can only be gained by an intensive study of the unusual conditions. This study must be pursued in the field of the social as well as in that of the physical sciences."(1)

The aim of my address is to draw attention to problems which require special study, and which, because they are in the main features common to many territories, call for collaboration between those territories in their study and in their treatment. Some of the problems cannot be dealt with effectively unless there is collaboration, and I shall find it necessary to indicate directions in which collaboration is possible.

In determining the area in which collaboration may be possible, it is desirable to have it large enough to cover the geographical extent of the common problems. In Africa, we have a large area of this kind, which also corresponds broadly with the area in which the overwhelming majority of Africans speak one form or other of the Bantu family of languages, and can be grouped culturally, as well as physically, as Bantu. The northern limit of the area runs in an irregular line, from the mouth of the Rio del Rey River, which separates Southern Nigeria from the Cameroons, eastwards through the Cameroons, French and Belgian Congo, Uganda, and Kenya. Having regard to existing and possible means of communication between the territories to the south of this line, the region, for practical purposes, should include the Belgian Congo,

Uganda, Kenya, and all the territories southwards. I hesitate to give this area a name, but if the term of Southern Africa could be accepted—it would be a convenient one.

Having earlier indicated that political topics are likely to create reactions unfavourable to inter-territorial collaboration, and having regard to the fields of study covered by Section F of this Association, I shall confine this address to social and economic aspects of the development of Africa.

Importance of Population Data.—The study of a country's population and vital statistics throws light upon many aspects of its life and problems, and studies of these aspects and problems in turn throw light upon the population and vital statistics. It is only within the past fifty years that there has grown a realisation of the importance of population and allied statistics in the study of social and economic problems, and in the framing of national and inter-national policies and programmes. They are now recognised as essential for measuring the need for, and the efficiency of, measures for the welfare of the people. " A peculiar significance attaches to the collection of vital statistics in Africa," says Lord Hailey in *An African Survey*. "Administrative questions of first importance, such as the regulation of the recruitment of labour, or the allocation of land for non-Native occupation or for Native reserves, cannot be satisfactorily dealt with in the absence of correct information of the present strength of the population and of its probable future trend. Accurate vital statistics supply the information on which the efficacy of the medical organisation depends, and, in particular, where such work has to be carried out with limited funds, it is essential to know where the need is most urgent; efficient planning for education depends upon knowledge of the number of children of school age; again, it is only by accurate population records that it is possible to settle many questions on which, at present, arbitrary assumptions are made, as, for instance, the effect on the birth-rate of Native customs, such as polygamy, or abstention from intercourse during a period of prolonged suckling."(2)

To this may be added that a study of migrant labour involves a study of the trends of population in the various African territories; that plans for the economic development of Southern Africa must take into account the geographical distribution of the population, and that Dominion collaboration on social security, now projected, cannot go far without a proper assessment of the age composition of the populations of the British dominions and colonies.

Lack of Statistics.—In Africa, however, nowhere is there to be found a satisfactory body of such vital statistics. In the Union, whose resources in men and money are greater than those of any other African territory, there is no comprehensive system of the registration of births, marriages and deaths, for most of the African people are not covered by our registration system. Nor is the census-taking accurate.

The nakedness of Africa in respect of reliable demographic material has been exposed by R. R. Kuczynski in the volume *The Cameroons and Togoland*—a demographic study, published in 1939,([3]) from which it is clear that neither British, nor French, nor German administrations in those areas had either adequate methods for the collection and collation of demographic material or adequate capacity for using such material.

As a footnote to these criticisms of West African territories, I may refer to the Union Census Report of 1921 and wild estimates of the future African population of the Union, and also to the absence of African data from the decennial censuses of 1931 and 1941.

It can be said that, in the area covered by this discussion, vital statistics are neither adequate nor accurate, nor are they based upon any uniform standard of enumeration. In the Union of South Africa, while the registration of births, marriages, and deaths is compulsory for all in urban areas, and for European, Coloured, and Asiatic races in rural areas, it is voluntary for Africans in rural areas, and as a result there is no registration of African births and deaths in most rural areas. Marital unions under Native custom, although not designated as marriages in law, are nevertheless, marriages sociologically. They are registered in Natal under the Natal Code of Native Law, but nowhere else. These facts have important effects upon the interpretation of the Union's demographic statistics.

Lack of Uniform Methods.—Methods of census taking vary considerably in Southern Africa. In some territories a rough count is taken of the number of huts in Native areas and an average number, say 3, is given for the children. In one territory, each Native Commissioner estimates the number of taxpayers and multiplies it by 3½ or 4 to get the total population. In the Belgian Congo, where no regular census has been taken, the administration relies on individual registration of every adult, male and female, and of children, on a card index register, which is checked annually by government agents who visit each tribal centre. Detailed statistics are made of sample centres to check the registrations. This appears to be the closest approximation to accuracy in Africa. There is also variation in racial classification between the various territories. There are many obstacles against the creation of a sound system of enumeration in Southern Africa: the scattered nature of populations; the ignorance and superstitious fears of the vast majority; the lack of funds and of trained personnel are some of the difficulties. "The varying degree of accuracy attained by the African population records," says Lord Hailey, "is not due only to practical obstacles, the administrations themselves have shown an unequal measure of interest in census operations." But the urgent need for measures to develop the economic resources of the various territories, and to raise the level of living of their peoples, makes it imperative that the data shall be available to guide those who have the responsibility for initiating such measures. It is

equally necessary that the data of the various territories shall be comparable and serve as the basis for collaboration between them on vital measures.

There should be no delay in making efforts to extend compulsory registration of births, marriages (including Native customary unions), and deaths in rural as well as in urban areas. There are regions in Southern Africa where it will be a long time before registration of these events can become effective, but it should be possible, in every territory, to select a sufficient number and variety of areas in which registration can be organised and adequately supervised to yield reliable results which could be used for generalisation.

The training of Africans for such work should be undertaken in all territories, either specially or as part of training for social work.

Both Carr-Saunders and Kuczinsky hold that there is not adequate material on which to calculate the present population trend in Africa south of the Sahara, and that we can only say that the population is probably decreasing; it may very likely be stationary, and it is not impossible that it may be increasing, but, if so, the rate of increase is certainly low.([4])

Dr. A. R. Paterson, formerly Director of Medical Services of Kenya, in a letter to me, expresses the view that he cannot avoid the conclusion that Africa is now on the eve of a gigantic increased population, just as Western Europe was in 1801 and as India was as late as 1921. Africa will never be able to export manufactured goods to buy grain for the feeding of the millions. ". . . Far from a rise in the standard of living—a material rise—bringing about a reduction of the Africa birthrate, it would seem that unless the birthrate falls very quickly the general standard of living will never rise." Until more adequate and reliable data are available, this statement must be accepted only as a warning that serious problems may arise without administrations having been prepared for them.

Material Available.—Notwithstanding the unsatisfactory nature of the demographic data available for Africa, particularly of a statistical kind, demographic studies in other parts of the world have yielded a body of knowledge of general application, which should be helpful to us in any study of the African population situation, and the directions which changes may take. There is, too, a growing body of knowledge in various spheres of study, such as anthropology, sociology, and medicine which will be helpful to us.

Low Population.—Africa as a whole is a continent of low density of population. South of the Sahara the density is almost 12 per square mile, a figure based upon uncertain estimates of population.([8]) This is low when compared with Europe (excluding the U.S.S.R.) 184, United States 41, Japan 439, India 195; but not when compared with Canada 2·9, and Australia 2·2. Just as in Europe and Asia there are areas which are densely populated, so in Africa there are areas which are more densely populated than the figure of 12 per

square mile would suggest. For example, in the Union as a whole the figure is 20·3, with the Transkei rising to 58·1.(5) In some of the Native areas of Kenya the density is high; for example, the average density in the Kikuyu Reserve is 283(6) as against 13 for Kenya as a whole.(8) In some areas of Nyasaland it is over 300,(8) as against twenty-five for Nyasaland as a whole. These concentrations of population were caused in some cases by the fear of the slave trade and in other cases by the fact that pasturage and cultivable land are to be found in widely separated areas. A close study of the distribution of the population will show that it has been affected not only by geographical and climatic factors but also by political, economic, cultural, and racial factors. A study of the rise or fall of the population will also show that some of the same factors have operated.

The total population of Africa does not appear to have moved much either up or down along the centuries.

Factors in Fecundity and Fertility.—The main factors in determining the rise or fall of population are, of course, the birth rate and the death rate. These may move in the same or in opposite directions.

Carr-Saunders expresses the view that " an increase in the birth rate played no important part in the expansion of the non-European people, or of the people of Eastern Europe. In Western Europe, however, social and other changes brought about a rise in the birth rate, although not a large rise. In all countries, however, the major factor was the decline in the death rate.(9) In the main, improvements in conditions making for better health were responsible for the expanding populations." The same authority classifies these conditions into four groups " though the boundaries between them are indefinite and though there is much overlapping: (1) political, that is, conditions relating to the maintenance of external and internal order; (2) social, including the state of knowledge in relation to the production and use of food, and to the making and use of clothing; (3) sanitary, that is conditions relating to housing, drainage, and water supply; (4) medical, including both the state of knowledge concerning the prevention and cure of disease and its application to the public at large.(9) A study of the political, economic, and social history of Europe seems to confirm this view, and this is true also of the countries of Asia, although the factors (2), (3) and (4) were late in coming into operation, and the death rates were correspondingly slower in coming down.

The rise in the birth rate in Western Europe was in some measure due to factors (2), (3) and (4), more particularly (4), but such gain has been lost in the greater drop in birth rate which has occurred in recent years.(10)

There are two main factors which determine birth rates; these are *fecundity* (the power of reproduction), and *fertility* (the degree of reproduction). The difference between the two terms

may be appreciated by saying that a woman may have power to give birth to twenty children but gives birth to four only. In that case, her fecundity would be twenty and her fertility four.([11])

It is held that there are three main factors " variations in any of which will affect fecundity. These are the length of the mature period, the interval between births, and the number of children."([12]) These factors are held to be themselves affected by food supply and physical conditions generally as well as by mental conditions; i.e., advances in arts and skills tend to create conditions favourable to increase. If these views are correct, and considerable evidence in support of them has been produced, it is easy to understand that improved social and economic conditions, resulting in better food supplies and betterment of the mental and physical life of the human race, enhances the power of reproduction.([13]) Low fecundity may be caused by poor nutrition, by endemic disease, and by excessive work undertaken by women. There is, for example, some evidence that the child-bearing period of African women has dropped in areas where food supplies have also dropped.

The fertility rate of the African people, apart from the effects of fecundity, has been affected by several factors, some of which are related to conditions of life, religious ideas, customs, and the will of the people, and others to the physical and climatic features of Africa.

Dr. Sonnabend has made a study of the factors which have influenced the fertility rate among certain tribes in Africa and the results were published in volumes published in Italian([14]). Unfortunately, no English translation exists, but Dr. Sonnabend has kindly supplied me with an outline of the main points which emerge from his study, and I have made use of them here. I have also made my own observations.

Among the main factors favourable to a high fertility rate was the African view of marriage as primarily for the production of children.([15]) " To have children and many of them is one of the great ambitions of our natives," say Smith and Dale writing of the Ila-speaking peoples of Northern Rhodesia. " Any man will tell you that to have children is one of the greatest desires of his heart. He who fails in this respect is regarded by others, and he regards himself, as something less than a man."([16]) The factors may be analysed as follows :—

(1) *Patriotism.*—As only a numerically strong tribe could maintain its freedom in a country where war was a constant menace, numbers were of paramount importance to the tribe, and no tribe was too large to appreciate at once any increase or decrease in numbers. Sterility was therefore highly unpopular and produced strong reactions.

(2) *Religion.*—Ancestor respect and the belief that ancestral spirits were re-embodied in new-born children (ancestral names being given in each case) created a strong

desire to perpetuate the ancestral stock and one's own personality and name.

(3) *Wealth and Status.*—The services of children were helpful in the care of stock and cultivation of crops; the lobolo received for the girls on their marriage added to the wealth of the family head and his various houses—"the more children, the more cattle." In polygamous society, too, the wives perform important economic functions, such as land cultivation, and the more there were in a family the more the economic burden was shared. Sons, too, grew up to relieve the father of need for active work. There were, therefore, strong economic motives for the raising of children. They built up economic security.

(4) *Status.*—Wives, children and cattle added to the prestige of the family head; they were the "*trinomium*" which conferred status and prestige upon the head of the family. The wives, too, derived pleasure from the number of co-wives.

(5) *Land.*—As long as land was freely available it was possible to meet the demands of increased population by the allocation of land. Every wife could be assured of land sufficient to maintain herself and the children of her house, and every son could hope to set up his own kraal, with pasturage enough for the cattle which his daughters would bring him on marriage.

(6) *Levirate and Sororate.*—The practice of these forms of marital unions ensured the continuance of the family where the father or the mother died.

Turning now to those customs and habits which tend to keep down the fertility rate, we find the following have been operative in Africa :—

(1) *Prolonged Lactation.*—Throughout Bantu Africa, and also in West Africa, we find that it has been the custom for mothers to suckle their infants for periods from eighteen months to three years, and even into the fourth year. Among most tribes, cohabitation of husband and wife during this period is taboo, or at least conception is prevented.(17) Almost every ethnographic record gives evidence of this practice. This has had a profound effect upon fertility.

(2) *Ritual and other Restrictions.*—Taboos in connection with war, bereavement, rain-making, and other seasonal observances have also had their effects upon the fertility rate in Africa.

(3) *Abortion (voluntary).*—The occasions for this practice are generally where conception has taken place after the breach of a taboo and after adultery. There is some evidence of abortion for economic reasons and because of war. As will be mentioned later, the desire for children among Africans is usually very strong so that the reason for abortion must be very great indeed. Never-

theless, the practice was general and was often on a considerable scale.[18]

(4) *Infanticide.*—Children were destroyed in certain circumstances. Peculiarities in the process of birth, and deformities in the body, the birth of twins, and the cutting of the upper teeth before the lower teeth are examples.

I have not included polygamy as a factor affecting the fertility rate either way, because there appears to be no conclusive evidence that polygamy has any effect upon fertility. Sonnabend holds that monogamous wives have a higher fertility rate because polygamous husbands observe the taboos mentioned above.

Apart from the unfavourable factors affecting the fertility rate, there were other features of life in Africa that affected the population situation, such as—

(5) *Ritual Murder and Witchcraft.*—These took a heavy toll of lives and the cumulative effect upon the population must have been great.[19]

(6) *Warfare.*—Inter-tribal and internecine warfare was a common practice of African life, but the loss of life was in no way comparable with that which takes place in modern warfare. There were, however, many instances of slaughter on a relatively large scale, such as during the Zulu and Matabele attacks on other tribes.

(7) *The Slave Trade.*—The depredations of the slave trade and their effects upon the population of Africa cannot be estimated, but they must have been very great.

(8) *Destruction by Wild Animals.*

(9) *Disease.*—There is ample evidence that diseases of various kinds were endemic and epidemic in Africa long before European settlement. " While the African is subject to most diseases which are known in temperate regions," says E. B. Worthington in *Science in Africa,*[20] " he is particularly a sufferer from others which are unknown or have disappeared wholly or partially from Europe, and are now looked upon as 'tropical' diseases." And he lists the following: Malaria, blackwater fever, the jungle type of yellow fever, sleeping sickness, plague, relapsing fever, typhus, tuberculosis, leprosy, helminthiasis, typhoid, dysentery, pneumonia, yaws, venereal diseases, tropical ulcer, scurvy, pellagra, beri-beri, and xerophthalmia.

(10) *Geographical and Climatic Conditions.*—Coupland, in his biography of Wilberforce, describes the effect of the geographical features of Africa upon immigration: " Cut off from Europe by the vast Sahara, the great mass of it lay for centuries outside the stream of history. Its unindented, harbourless, inhospitable coast, the bars and rapids of its few great rivers, the deadly climate of its tropical belt made exploration difficult and unattractive . . . " This was Africa as viewed from the west. From the north and the east it was more penetrable, but no large-scale immigration seems to have taken place, due, no doubt, to the discouraging effects of the

African climate and diseases and the poor nature of the soil in Africa generally which make continuous agricultural settlement impossible. Large areas are uninhabitable because of the tsetse fly—two-thirds of Tanganyika, one-seventh of Kenya, and one-third of Uganda. The climate, too, in the tropical belt particularly, was a deterrent to immigration. Little is known, however, of the effects of climate upon fecundity. Thus the cultural tides of Asia and Europe did no more than lap on the African beaches with an occasional trickle overflowing into the interior.

It is clear then that physical, biological, social, and psychological forces operated to keep the population of Africa low.

Effects of Cultural Contacts.—What changes have come with European settlement and capital investment in Africa? "The traditional social-economic order of Native society," says E. B. Worthington, "is being changed by world economic conditions, which are quite beyond the control of Africa itself. Thus the cultivation of new crops for the world's markets, and the demands for labour for European enterprises have profound and far-reaching effects on the family, the tribal organisation, religious beliefs and sanctions, traditional morality, and other branches of social structure. The effect of these changes may be disastrous unless there is an understanding of the native social and economic systems, and unless an attempt is made on the basis of adequate knowledge to replace them, where they are breaking down, by new incentives to labour, new values and new economic wants.([21]). Similar shocks to Native society have been given by the superimposition of White rule upon that of traditional African authority, or as in so many cases, the substitution of European rule for African; by the large-scale migration of Africans long distances from their homes for ever-lengthening periods of labour service and residence in other territories; and by the impact of European patterns of conduct and European social institutions upon African traditional modes of life. We fortunately have a number of studies of but effects of such contacts and changes upon African tribes, the hardly any which indicate their effects upon the trend of population.

The restriction of the African's occupation of land has had profound effects upon some of those customs which favoured fertility, such as the passing of *lobolo* cattle, and the allocation of adequate land for each house. Cattle are less able to resist drought and disease, and large numbers die, while Government efforts to reduce the number of cattle by taxation and by pressure to sell have had depressing effects upon the social and economic status of the African. Lobolo tends more and more in such situations to be passed in cash, which is soon dissipated, leaving the inter-family relationship without the nexus which cattle provide, and reducing the economic security of the family. In urban areas, especially, this situation is developing quickly.

The present trend of Bantu populations as they appear in official statistics is upwards. The age composition appears to be favourable, and the birth rate is correspondingly high. Mortality

is also high. Infant mortality, especially, appears to be very great, although perhaps not as high as 500 per 1,000 as some records have it—a rate which, as Kuczinsky has pointed out, would mean the elimination of the race. If, as in India, the death rate dropped dramatically, the rate of increase of population would rise sharply, *if no other factor affected the birth rate.* It is possible that urbanisation will lead to a drop in the birth rate as the favourable factors lose force, or are eliminated, such as the availability of land. Racial friction—due to such causes as the colour bar, riots (between White and Black), housing difficulties, high cost of living, and adverse political measures—may have a depressing effect upon the race.

Pitt-Rivers' study of the effects of European settlement upon the peoples of Melanesia, whatever its merits, indicates the type of study that is required. The correlation of quantitative and qualitative analysis of population trends in Africa is urgently necessary, but the quantitative data are inadequate and faulty, and the qualitative material is inadequate. We do not know enough about the effects upon African fertility of the social and economic changes which have been taking place as a result of the advent of the European. In his *Primitive Economics of the Maoris*, Firth says: " It seems probable that the sequence of phases in culture contact which has been revealed in Maori economic history may have a wider sociological import."(22) I believe also that it has also a profound psychological significance and a strong bearing upon population trend.

Pitt-Rivers, in *The Clash of Culture and Contact of Races*,(23) while noting that census figures for the Maoris prior to 1906 are unreliable, quotes an estimate made by Sir George Grey, when Governor of New Zealand in 1941, of a Maori population of 120,000. Colonial Government figures in 1896 showed a population of under 40,000. Since 1902 " there has been an apparent slight but steady increase".

I suggest to the various administrations of Southern Africa that demographic and anthropological studies, along the lines I have indicated in this address, should be instituted and encouraged and regarded as of primary importance for the formulation of policies and programmes for African development, which must depend upon the availability of African manpower for their execution.

Under-development.—Africa is under-populated in relation to the total area of the continent, but is not under-populated in relation to the resources of the people to maintain the population. As Carr-Saunders has said: " Africa is an under-developed continent; it is not underpopulated having regard to the resources of the native inhabitants, though it might accommodate without inconvenience a slightly more dense population in certain areas. . . . If Africa is to support a much larger population, the whole scheme of African life must be transformed."(36)

On the other hand, the development of the continent is dependent upon there being available the population to undertake the

economic and other activities necessary for that development. "The greater the degree of development," says Professor S. H. Frankel, "the more pressing will the question of population and therefore the supply of labour become. From an economic point of view, Africa is under-populated in the sense that the number of its people available for modern economic activities is smaller, with their present educational and sociological standards, than the exploitation of its resources required."(24) On the other hand, the factors making for an increase in population depend upon the "good conditions" mentioned earlier in this address.

Health Conditions.—Among the "good conditions" necessary for increasing population are those of health. In Africa, the two chief causes of ill-health are parasitic diseases and under-nutrition. Their effects upon the fertility rate of the African people have never been considered, nor have the effects upon their economic *productive* power been appreciated. Among parasitic diseases of major incidence in Africa are :

(*a*) *Malaria.*—"In general," says Worthington, "anti-malarial work in Africa is hampered by ignorance. What are the real effects of malaria? It is well known that, over vast areas of the country, practically the entire African population above one year of age harbour malaria parasites in their blood continuously, but, as yet, little knowledge is available as to the effects of this condition at different age-periods in terms of sickness, mortality, general well-being, and working capacity. . . . In the native reserves of Kenya the disease is endemic in from 30 per cent. to 80 per cent. of the people; in the Eastern Province of Uganda the percentage of children with parasites in their blood was found to reach 80 per cent and of those with enlarged spleens 96 per cent."(25)

(*b*) *Sleeping Sickness.*—In the four years 1901–1905, some 300,000 people died of sleeping sickness in the immediate neighbourhood of Victoria Nyanza. Fortunately, the incidence of sleeping sickness has dropped greatly. Increase in travel—and Africans are great travellers—tends to spread infection in this as in other cases, and there is evidence of a higher incidence in Nigeria, where it is estimated that in the Northern Province there are nearly a million cases. In other parts of Africa, its incidence may be higher than is realised, because the presence of the disease is not appreciated. A victim may suffer for many years from general weakness, and with resistance lowered, he may succumb to another disease.(26)

(*c*) *Helminthiasis.*—This term covers a multitude of parasitic worms, such as Ancylostoma (Hookworm), and Schistosoma (Bilharzia). "Helminthiasis as a whole is regarded as of very great importance in many African territories. In East Africa it has been estimated that over 90 per cent. of the population are infected with one or more kinds of helminth, and frequently as many as six kinds have been found in the same individual."(27) In the Union of South Africa, Bilharzia reaches the incidence of 50 per cent. of the Native population in certain areas. In Northern Rhodesia, 31 per

cent. of the workmen recruited by the Rhokana Corporation have been found to have Hookworm. In Nyasaland, 140 out of 1,494 cases at the Zomba Native hospital were admitted for Hookworm and 47·2 per cent. of all other cases were infested with these helminths. In one district, 100 per cent. of the people examined harboured the parasite. In Northern Nyasaland, a heavy child mortality was traced to intestinal infection by worms resulting in cirrhosis of the liver. In Kenya, a village healthier than others was examined at the end of the dry season, when Hookworm should be lowest, and every individual was found to be infected.([28])

(*d*) *Yaws and Venereal Diseases.*—Estimates of these diseases are usually unreliable, partly because it is difficult to distinguish between yaws and syphilis, and partly because many sufferers do not submit to treatment in European hospitals until the late stages. Worthington considers that "throughout Africa there is no doubt that these diseases must be regarded as of far greater importance than the more obvious diseases, with the exception perhaps of malaria and sleeping sickness.([29])

(*e*) *Tuberculosis.*—This is one of the white man's contributions to Africa, and it is now distributed throughout the continent, the African contracting it in a very much more virulent form than the European. Here is a case where changes in African modes of life effected by culture contacts have provided favourable conditions for the disease. This was pointed out by a committee of the S.A. Institute of Medical Research which investigated tuberculosis among mine labourers in 1925–32. In its report,([30]) the Committee pointed out how the Hut Tax tended to reduce the number of huts occupied by a family and to increase the risk of infection. The decline in the practice of burning the huts of the dead also had this result.([31])

(*f*) *Typhus.*—There is a close correlation between the incidence of this disease and the nutritional condition of the people. In the Union typhus has flared up alarmingly during times of economic distress in Native areas, and a heavy toll of life has always resulted. It is now realised that typhus in one form or another is more prevalent in various parts of Southern Africa than was realised.

There is no need to deal with the other parasitical diseases in order to bring out the burden of disease which the African carries. Some of the diseases mentioned are known to affect the fertility rate (such as Gonorrhoea and Bilharzia), all lower the vitality of the African.

The elimination of parasitical diseases will require, not only large scale internal organisation and expenditure within each territory, but also close collaboration between the various administrations in Africa. This is a field where regional collaboration would prove of the greatest benefit to the continent. The elimination of these diseases would release the human energy which is now sapped by disease. The capital value of this wasted energy must be enormous, and its recovery would amply repay the expenditure involved in

the elimination of these parasitic diseases. This is a task which the United Nations Organisation might well sponsor, and the Rockefeller Foundation's experience of large-scale operations of this kind would prove of the greatest advantage, if it agreed to help.

Nutrition.—There are also the deficiency diseases to be taken into account. Appreciation of the part which poor nutrition plays in producing ill-health is of recent date, but two world wars have emphasised its importance, and as a result there are now many efforts to survey the extent and effects of poor nutrition in Africa, as in other parts of the world. Nutritional standards vary, and it is therefore not possible to be sure of statistical data supplied as to the extent of under-nutrition. The *specific* diseases which have their origin in poor nutrition do, however, submit to more objective diagnosis. Fox's work in the Union on Nutrition among the African people has, however, attracted world-wide notice and has yielded data of great importance. He has pointed out that the African's traditional diet, even under the most favourable conditions, was so finely balanced that the elimination of any one element must have serious effects upon his nutritional condition.

It would be easy to quote from large numbers of medical and other reports from various parts of Southern Africa to show that the nutritional condition of the African population is causing anxiety to the authorities.

Dr. B. S. Platt, Director of the Human Nutrition Research Unit of the (British) Medical Research Council, reporting on a study, in Nyasaland in 1938-39, of the inhabitants of three rural villages and a number of families in an urbanised area, said that the people "are not getting enough food to enable them to do a day's work nor are they getting enough of some nutrients to maintain them in a reasonably satisfactory state of health and resistance to disease.([32])

Throughout Southern Africa, there are areas where the balance of the traditional diet has been upset by the disappearance of the wild spinaches, roots, and other elements of the diet, because of over-grazing, and where the water supply and the soil have deteriorated through over-grazing and over-cultivation, with disastrous results to the food supply. When the African was not too restricted in the land holding, he met the need of the soil, for rest and regeneration, by shifting cultivation, and it is now realised that he was more fully aware of this need than he has been given credit for, and has a closer acquaintance with the relation between soil and vegetation than has been realised by European agriculturists.

The unwillingness of Africans to co-operate with their European rulers in measures for the conservation of the soil, such as the limitation of cattle, is a protest against their restriction to small holdings and their inability to carry out the traditional shifting cultivation. As one African said to me when I pleaded for restriction of cattle: " No, not too many cattle, but too little land." Somehow or other, we have to build up a new peasantry under the restrictive

conditions which the land situation in Africa demands, but we have also to find a way of using the traditional knowledge and experience of the African more than has been the case in the past. Studies, such as Dr. Audrey Richards' study of the diet habits of the Bantu in Northern Rhodesia,[33] are necessary for a proper approach to the African people to secure their co-operation in improving their nutritional condition and for a right understanding of the nature of the problem. Here is a field where team-work is particularly necessary between sociologists (including anthropologists), economists, agriculturalists, dietitians, and medical and public health experts. Such diseases as tuberculosis, pellagra, tropical ulcers, and scurvy can only be eliminated by raising the levels of living which depend upon economic effort, upon education, and upon the co-operation of the people with medical and health authorities.

It is clear that the "good conditions" of health necessary to increase the African population are not available to-day, and it is doubtful if, under existing conditions, a decline in the population can be prevented.

Poverty and Ignorance.—The unfavourable health situation reflects the low social and economic level of African life, and this aspect was emphasised by Dr. C. Wilcocks (who has done considerable medical research in Africa), during a discussion at the Royal Society of Tropical Medicine and Hygiene in 1946.

It is quite true that the basic problems of Africa are poverty and ignorance. These gigantic diseases will not be eliminated without the economic resources necessary to provide the funds for large-scale operations, without the economic basis to maintain an adequate standard of living, and without the intelligent co-operation of the people in sound habits of diet and hygiene.

In my visits to several African territories, I have been impressed by the magnitude of the tasks which face administrations and by the utter inadequacy of their resources to deal with them. Economic development must provide the basis for other developments.

This was well-expressed by Sir Philip Mitchell, Governor of Kenya, in a despatch to the Secretary of State for the Colonies last year: "(The major problem) can be stated simply and plainly by saying that an ignorant man and his wife with a hoe are a totally inadequate foundation for an enlightened society, a high standard of living and elaborate social services, and that unless an alternative foundation, capable of bearing these things can be devised, or, when it exists, can be expanded, a great deal of modern talking and writing about colonial development and welfare is moonshine."

Western Economy Needed.—But the economic development of Africa will not come out of the simple undifferentiated economy of African society. The African cannot raise himself by his own efforts alone. African traditional economy never can provide the capital for the developments necessary for saving Africa from the ravages of disease.

This is well expressed by Lord Hailey :[34]

"If African administrations are able to attain to higher standards of expenditure on social improvements, the African population must pay the price which is necessary to earn them. Any substantial improvement in taxable capacity will involve a far greater measure of differentiation in the constitution of society, the growth of specialised types of occupation, and the individualisation both of effort and of the prospects which effort earns. There are those who will view with some distress anything which tends to substitute the disastrous atomization of western society for the organic unity which African society still possesses. It may be answered that western society is finding that it is possible to combine a common social purpose with an advanced degree of economic individualism. But whatever value is to be attached to this consideration, it is not open to doubt that the African peoples cannot hope to provide themselves with the resources needed for a material development of their social services, without a change in many of the social conceptions which determine the character of their economic life."

In no direction is the introduction of western economy more urgently necessary than on the land. There is no hope for the African on the land as long as he is dependent upon his own resources for advancement. In Eastern Belgian Congo, Uganda, Kenya, Nyasaland, Northern Rhodesia, Southern Rhodesia, the Union, and the Protectorates, the Africans cannot maintain themselves on the land, and as they acquire new wants the task becomes more and more impossible. The Nyasaland report quoted earlier showed, that as Africans go out to work for their own and their families' cash needs, the food crops at home drop because they are not there to cultivate the land. And, as their own and their families' acquaintance with western life widens, their social and economic needs increase, and the periods of outside employment extend. And so, in most if not all the territories of Southern Africa, there are streams of migrants travelling between the rural and the industrial and commercial areas. Meanwhile, the agricultural areas deteriorate.

Land Development.—For many years I have urged that the development of an African peasantry, able to maintain a satisfactory and progressive level of living on the land, depends upon the African being a fulltime worker on the land and upon his production being adequate for the task. This view has, in so far as the Union is concerned, recently been endorsed by the Social and Economic Planning Council. It involves the re-organisation of Native areas so that those who hold land shall be required to be beneficial occupiers. But this will not be enough. The Native areas have not the capital necessary for development, and capital will have to be introduced from outside, with the necessary organisation of production and marketing.

What can be achieved in these ways has been shown by the experiment the Sudan Government several years ago initiated in the Gezira area, between the Blue and White Nile. The Government came to the conclusion that the traditional economy of the

Fellaheen, who occupied that area, would never give them the means for upliftment. The Government decided to irrigate the area, and to reorganise the holdings and the methods of production. It entered into an arrangement with a financial group in London, who set up a syndicate—the Sudan Plantations Syndicate—to undertake the organisation of the Fellaheen's cultivation of the land and the marketing of the staple crop—cotton. The arrangement provided for a division of the profits between the Fellaheen, the Government (which was responsible for the capital and maintenance costs of irrigation) and the syndicate, these being divided on the percentage basis of 40, 40 and 20 for the respective parties. The scheme has been successful. In 1925, 240,000 acres were under cultivation, in 1938, 850,000 acres; and soon it is expected that the figure will rise to 1,600,000 acres.([35]) Recently the Government has taken over the functions of the Sudan Plantations Syndicate.

The most recent instance of this kind of co-operation between Government, people, and private enterprise is that now being initiated in Tanganyika, where the United Africa Company will operate a ground-nut industry for the British Administration, and will enable the African cultivator to raise his productive capacity many-fold, and to advance his level of living considerably.

In the Union, it should be possible for the South African Native Trust to reorganise the impoverished Native areas in some such way.

Education.—With the economic reorganisation of Native areas in Africa must go the education of Africans to enable them to be intelligent participators in the economic activities that are to advance them. There is an enormous wastage caused by the illiteracy of the Africans. The pace of economic activities in Africa is held back because instruction must be oral. Administration is slower and more clumsy because the written word is not understood. The effectiveness of health and agricultural propaganda is limited, because so many of the public which it is designed to reach do not read and do not understand pictures. Literacy is the first of the requirements for progress. The mass Education programme of the British Colonial Office and the literary experiment of the S.A. Institute of Race Relations are steps in the right direction.

The training of Africans for service, to lead their people to an understanding of what is happening to them in modern Africa, and of what is expected of them for their own advancement, is another primary need in education.

The Essential Ends.—Africa is faced with gigantic tasks in reconstruction and development. These tasks call for vision, understanding, and courage. They demand the mobilisation of all the constructive forces of modern civilisation and their application to Africa. They call for full collaboration between the administrations, and, for these tasks, all the potential energies of the African—now so deplorably held back by ignorance, wasted by disease, and frustrated by racial barriers—must be harnessed to make the African a willing worker for the advancement of Africa.

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A NOTE ON SOME CONSEQUENCES OF THE HEISENBERG PRINCIPLE OF INDETERMINACY

BY

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ABSTRACT

Application of the Principle of Indeterminacy to the atomic nucleus leads to the following conclusions :

(i) the nucleus can not contain free electrons ;

(ii) the nuclear energy levels are of considerable width, which decreases with increasing mass number ;

(iii) the smallest particle that can be retained within the deuteron has a mass of about 130 times that of the electron, and therefore corresponds to the mesotron.

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ATOMIC ENERGY IN PEACE AND WAR

BY

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Abstract.

Atomic or Nuclear energy is dealt with in this paper mainly from the Naval Service point of view. In so far as ships are concerned, the effect of the transition from oil fuel to atomic power will be as revolutionary as the change from sails to steam has been. With nuclear Energy as the motive power, boilers and associated auxiliaries would become superfluous, the space occupied by thousands of tons of fuel would be available for cargo, machinery and cabins, the structure of hulls would be materially strengthened, and since economy of fuel would no longer be essential, turbines could be designed with greatly increased horsepower, making high speeds available. A complete alteration of the underwater body of ships would further result in their cruising radius of action being limited only by the amount of provisions carried. The use of atomic power in the merchant marine, which would then cease to carry huge loads of fuel, might prove commercially advantageous even earlier than atomic power plants on land.

Changes in the construction of warships will probably be as great as those which progress in guns and gunnery, the use of disruptive shells and the invention of slow-burning powders, torpedoes and mines had effected.

The most interesting changes may be those effected in submarines, in spite of the weight of the "pile." The greatly increased submerged speeds and radii of action will put the submarine into a special class as a means of transportation and as a major combatant unit. This view is supported by the fact that submarines, as the Bikini tests revealed, are able to withstand the shattering effects of the atom bomb and of lethal radiation much better than surface vessels. Many authorities consider the submarine as the warship of the future.

Military Applications.

Besides the production of atomic munitions, atomic energy will probably be utilised for the transport of troops, ammunition, food, weapons and other military impedimenta. As motive power for aeroplanes, rockets and ships, atomic energy will result in an increase in their range, in ships becoming more independent of refuelling bases, and having more room for cargo, machinery and arms.

The necessary changes in the construction of warships indicated by the knowledge of atomic weapons hitherto gained, will be embodied in the first capital ships of the atomic era now being built by the U. S. Navy, viz. the 45,000 ton battleship *Kentucky*, and the 27,000 ton battlecruiser *Hawaii*. Among these changes will be the toughening of hulls, the protection of crews against the lethal effects of radio-activity, the protection of delicate instruments, the installation of rocket-launching tubes and other missile-guides in place of great guns.

SEA POWER.

This results from a combination of forces applied by surface and sub-surface war vessels and contrivances and by aircraft and merchant shipping, which gives the user the command of the sea for his purposes and refusing it to an enemy. As long as carriage by sea remains the only practicable method of moving about the world armies in force and great masses of supplies for both soldiers and civilians, sea power will be a deciding factor in war. The development of the aeroplane, which has been considered by some to deal a final blow to sea power, has actually introduced into war at sea an entirely new capital ship, the aircraft carrier, which has become the chief striking force of modern navies.

It must however be borne in mind that sea power does not consist merely of battleships, cruisers, destroyers, aircraft carriers and submarines or even of the sum of all these things which only represents the material part of sea power, the force necessary for applying sea power. Merchant shipping is one component of sea power without which it is impossible to move from place to place troops, munitions, food, weapons and other things necessary for waging war. Nevertheless without bases, harbours, and skilled men trained in all the arts necessary to keep the shipping industry in effective action, sea power cannot exist.

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FURTHER REMARKS ON THE LANGEBAAN PHOSPHATE ROCK.

BY

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Read July 2nd 1947.

The Langebaan phosphate rock is attacked by even very dilute acids with evolution of carbon dioxide; this property is characteristic of the carbonate-apatites. It is therefore necessary to enquire whether the phosphate mineral in the Langebaan rocks is a carbonate-apatite or, as stated previously (Frankel, 1942), a sub-micro-crystalline fluor-apatite.

Thewlis et al. (1939) regard carbonate-apatite as mixtures of apatite and calcite. On the other hand, de Villiers (1942) and Hutton and Seelye (1942), regard the carbon present as part of the apatite molecule, replacing phosphorus and calcium. In support of their view Thewlis and his co-workers stated that they could detect only apatite from a study of X-ray photographs of apatites containing carbon dioxide and they referred to earlier work which showed that less than ten per cent. of calcium carbonate was not detectable when mixed with hydroxy-apatite. Their samples had contained less than ten per cent. of calcium carbonate.

None of the analyses, corrected after removal of impurities, quoted by Haughton (1932) and only two of those cited by Frankel show an amount of carbon dioxide sufficient to give over ten per cent. of calcium carbonate. Thin sections of the Langebaan rock have revealed no calcite, nor have any lines referable to calcite been detected in the X-ray photographs. Thus, unless calcite is present in a sub-microscopical intergrowth with the crypto-crystalline apatite, some of the carbon present may be assumed to replace phosphorus and perhaps, calcium.

A better idea of the composition of the pure phosphate mineral is obtained by recalculating the analyses in the original paper to eliminate impurities. Silica, titania, ferric oxide and moisture were disregarded and in the case of the phosphatised clay, the combined water was adjusted to allow for the amount present in the clay minerals. It is obvious that in the other analyses the portion of combined water in opal and clay should be removed; but the true amount is difficult to estimate and so this water has been left. In any event the recalculated analyses would not be affected to any

marked degree. No attempt could be made to determine the distribution of the atoms in the molecule because of the difficulties concerning the combined water just mentioned, as well as the uncertainty of the true carbon dioxide content of the apatite mineral.

TABLE I

	a	b	c	d	e	f
P_2O_5	33·35	36·75	33·20	38·25	35·01	42·3
CaO	54·57	55·80	53·31	54·64	54·84	55·5
F	3·26	3·33	2·98	2.80	5·60	3·8
$H_2O(+110°C)$	4·91	1·40	5·38	0·66	1·51	—
CO_2	4·89	4·00	7·63	1·98	4·43	—
Other Constituents	—	—	—	2·38	1·27	—
	100·98	101·28	102·50	100·71	102·66	101·6
Less O for F	1·37	1·40	1·25	1·18	2·36	1·6
	99.61	99.88	101.25	99.53	100.30	100.0

a,b,c. Recalculated analyses from Frankel, 1942. p. 103.
d. Francolite, Deans, 1938.
e. Francolite, de Villiers, 1942.
f. Fluor-apatite.

The recalculated analyses show a general resemblance to published analyses of francolite, and these together with the refractive index and X-ray data make it reasonable to regard the Langebaan rock as a variety of francolite. It should be noted that the X-ray photographs of fluor-apatite, francolite and the Langebaan phosphate are extraordinarily similar.

For the following recalculated analyses, Table 2, it is rather more difficult to explain why the CaO/P_2O_5 ratio is below that found in either the theoretical fluor-apatite or the average francolite. It may be that as originally suggested, the excess of P_2O_5 is associated in some form of complex aluminium iron phosphate ; alternatively in these cases, the carbon may replace calcium and phosphorus.

TABLE 2

	a.	b.	c.	d.	e.
P_2O_5	41·92	41·26	40·9	39·3	34·8
CaO	48·92	48·46	50·1	52·1	47·9
F	2·56	2·88			
H_2O (+110°C)	3·75	5·01			
CO_2	2·10	2·47			
	99·25	100·08			

Recalculated Analyses.
a. Nodule, white portion } Frankel, 1942, p. 105
b. Nodule, brown portion }
c. SH 1424. Sandy nodule }
d. SH 1427. Nodule from main band } Haughton, 1932, pp. 121-122.
e. SH 1618. Nodule from near base }

Hutton and Seelye suggest that francolite in which calcium only is replaced by carbon has a negligibly small birefringence. De Villiers points out that information on this matter is not yet available. However, a study of the above recalculated analyses

and the fact that the Langebaan phosphate is virtually isotropic, point strongly to a replacement of calcium by carbon.

During dehydration experiments on Langebaan phosphate there was no marked evolution of carbon dioxide at any stage of heating ; nor more particularly between 500 and 600 °C as in the mineral calcite. The results obtained were plotted as loss in weight against temperature and the curves produced were similar for both the white and brown portions of the nodules. These curves also showed a general similarity to the curve prepared by Hutton and Seelye. This additional information therefore, suggests an apatite with the carbon as an integral part of the molecule.

The views expressed above do not modify the suggested mode of origin of the phosphate given in the earlier paper, nor do they eliminate the possible presence of some hydroxy-fluor apatite or even of sub-microcrystalline apatite.

Summary

A review of evidence in an earlier paper leads to the conclusion that most of the phosphate mineral in the Langebaan phosphate rock is a variety of carbonate-apatite (francolite), and not all pure sub-microcrystalline fluor-apatite.

The original data supplemented by temperature/weight-loss experiments support the view that the carbon is an essential constituent of the phosphate mineral and furnish no evidence of the presence of free calcium carbonate.

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RECENT DEVELOPMENTS OF THE CYCLOTRON

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THE BAROTSES IN PORTUGUESE EAST AFRICA.

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THE FOWLER COLLECTION OF FOSSILS FROM KOFFIEFONTEIN, O.F.S.

BY

DR. H. B. S. COOKE.

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DEPRIVATION OF LIBERTY AND PSYCHIC ATAVISI

BY

DR. H. HUSSERL.

Read July 2nd, 1947.

ELEMENTARY TREATMENT OF THE BREAKING OF AN INDUCTIVE CIRCUIT.

BY

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GENERAL PICTURE OF THE CLIMATIC CONDITIONS IN MOZAMBIQUE.

BY

DR. J. DE OLIVEIRA BOLÉO

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This paper does not fully cover the subject of the Mozambique climates, as the time assigned to me for the work was rather short. I would recommend the bibliography given at the end to those who may be interested in a further study of the subject.

My main purpose is to assist South African geographers in respect to the climatology of Mozambique, so that when it is found desirable to study the meridional African sub-continent as a whole, a source of information to assist in correlating the Portuguese Territory with the adjacent climatic areas of the Union of South Africa, Swaziland, Rhodesia and Tanganyika may be available.

The study of climatology is also of great importance for explaining the varying distribution of plant and animal life and of human races in different regions. It is also essentially a key to the understanding of the physical features of a region, their evolution, weathering, etc.

It is advisable to emphasize at this stage that climatology is not meteorology. The latter concerns the geographer only in a subsidiary manner, while the former interests him fundamentally —as its objective is primarily the comprehension of the complex formed by the atmospheric conditions typical of any particular region. That complex determines whether a region is capable of providing, to any degree, healthy existence and sustenance for any human race, or for the development of plants and animals useful to mankind.

The study of meteorology has different aims, although its data are utilised by climatology.

THE COLONY OF MOZAMBIQUE.

Pressure Gradient and Wind. This colony is situated between the 10° 27'S. and the 26° 51'S. parallels, and is divided into two zones of meteorological regimes. One, to the North, is under the influence of the monsoons, the other, to the South, is already in the path of cyclonic centres of medium latitudes.

The transition from one zone to the other is smooth, but one can say that the regions on the banks of the Zambesi (districts of Tete, Quelimane, and the northern part of the Beira district) constitute the areas linking the two great zones.

The North-east monsoon blows from October to March, and the South-east monsoon from May to August.

The rains brought by the maritime monsoon from the N.E. are abundant from December, but April is already a transition month. At that time of the year, the "monomucaias" or hurricanes, are quite frequent, and often so violent as to cause great damage over the coastal areas.

The South zone, affected by the depressions and anti-cyclones of the medium latitudes, does not however, allow of a clear separation between the four seasons of the year. One can distinguish a hot and rainy season from November to March, and a cold, dry or dewy season from May to September, whilst April and October are transition months.

An anti-cyclonic regime prevails in the South of the Continent during the cool season, and the permanent anti-cyclonic centers of the South Atlantic and South Indian Oceans unite, with highest pressure values reaching over the Cape Province, at short distances from the coast.

The zone of low equatorial pressures often sends out an extension to the South, which goes down the western African coast and forces the southern anti-cyclonic center to subdivide into two. This depression goes round the coast, the anti-cyclone unites again, and at times causes minimum rainfall in the Province of Natal, and in the South of Portuguese East Africa ; the depression dies away in the gulf of Sofala.

A regime of low pressures caused by the southern meridian declination, however, prevails during the hot season, so that the anti-cyclonic area of the South breaks into the two classic sections : Atlantic and Indian.

The passage of depressions gives rise to strong winds and frequent thunder-storms, followed in most cases by very heavy rain.

Temperatures. Knowing the annual pressure distribution we may now look at our isothermal chart. (Plate 1)

The influence of latitude, of altitude and of the hot stream of Mozambique, is very marked. As a rule the annual mean temperature in the coastal areas increases northwards from 22° to 26°C.

The annual changes are more marked in the South than in the North ; and the same can be said of the daily variations.

The influence of the hot Mozambique stream can be judged by comparing the average temperatures at Durban, 234 miles to the South of Lourenco Marques with those of the capital. Durban's annual mean is only 0.6°C. lower than that of the Mozambique capital ; its January average is identical, and the July average is only 1.1°C lower.

In the zones of the interior of Mozambique less than 400 metres above sea-level, the temperature changes are more marked, following the laws that predominate in the interior of continents. In mountainous areas 1,000 metres above sea-level, temperatures also become milder throughout the year.

Other conclusions may be drawn from the following tables.

TABLE 1 LOW ZONES (less than 400 m. above S.L.) Northwards, Temperatures.

Localities	South Latitude	Long. East of Greenwich.	Altitude (m.)	Annual Mean Temperature	Maximum average	Minimum average	Average Range	Absolute Maximum	Absolute Minimum
	° ′	° ′		°	°	°	°	°	°
East London	33 2	27 23	6	18,2	—	—	—	38,3	2,8
Durban	29 51	31 00	79	21,6	—	—	—	43,1	5,7
Bela Vista	26 20	32 41	15	22,6	27,6	17,3	10,3	42,9	3,5
Lourenço Marques	25 58	32 36	59	22,0	27,6	17,6	10,0	45,4	7,2
Moamba	25 36	32 14	110	23,3	30,1	16.1	14,0	46,0	1,0
Manjacaze	24 43	33 51	65	23,6	29,7	16,9	12,8	45,0	4,0
Quissico	24 43	34 45	150	23,1	27,4	19,2	8,2	40,0	10,0
Inhambane	23 53	35 23	14	23,7	27,0	20,4	6,6	35,5	11,0
Zimane	22 03	34 08	—	23,5	28,6	14,4	14,2	40,5	0,5
Beira	19 50	34 51	7	24,2	29,2	19,9	9,3	43,0	8,7
Quelimane	17 53	36 53	6	24,5	29,8	19,8	10,0	42,7	7,0
Chemba	17 12	34 53	59	25,6	32,5	19,0	13,5	45,3	6,7
António Enes	16 45	39 14	4	25,9	29,9	21,0	8,9	40,1	6,5
Tete	16 09	33 35	111	27,0	32, 7	21,1	11,6	46,2	10,5
Zumbo	15 37	30 37	335	25,8	31,6	18,7	12,9	46,5	5,7
Mossuril	14 57	40 40	15	25,5	30,4	21,0	9,4	38,4	12,6
Nacala	14 31	40 38	24	26,7	31,4	20,8	10,6	40,0	10,5
Namapa	13 45	39 50	200	25,4	32,4	17,9	14,5	42,0	7,2
Mocímboa da Praia	11 19	40 22	27	26,0	30,6	20,4	10,2	38,0	11,0

TABLE 2 MEDIAN ZONES (400 to 1,000 m. above S.L.) Northwards, Temperatures.

Localities	South Latitude	Long. East of Greenwich.	Altitude (m.)	Annual Mean Temperature	Maximum average	Minimum average	Average Range	Absolute Maximum	Absolute Minimum
	° ′	° ′		°	°	°	°	°	°
Namaacha	25 59	32 01	594	20,5	27,3	13,7	13,6	40,5	3,5
Macequece	18 56	32 52	703	21,4	28,2	13,5	14,7	42,0	0,0
Vila Gouveia	18 04	33 12	661	22,4	29,2	14,1	15,1	45,3	0,5
Alto Molócué	15 38	37 41	563	22,8	28,7	16,3	12,4	41,0	4,0
Nampula	15 07	39 15	442	24,4	29,3	18,9	10,4	40,0	1,5
Ribáuè	14 57	38 19	530	24,1	30,2	17,2	13,0	45,0	0,1
Montepuez	13 08	39 07	560	24,3	29,7	17 3	12,4	39,0	0,0
Mueda	11 40	39 33	847	21,5	26,6	16,0	10,6	33,0	3,5

TABLE 3 HILLY ZONES (more than 1,000 m. above S.L.) Northwards Temperatures.

Localities	South Latitude	Long. East of Greenwich.	Altitude (m.)	Annual Mean Temperature	Maximum average	Minimum average	Average Range	Absolute Maximum	Absolute Minimum
	° ′	° ′		°	°	°	°	°	°
Espungabera	20 28	32 46	1.050	19,4	24,7	14,5	10,2	39,0	2,0
Vila Vasco da Gama	14 54	32 16	1.153	20,0	24,8	15,1	9,7	38,0	6,2
Furancungo	14 54	33 36	1.260	19,2	24,9	12,7	12,2	39,5	0,7
Vila Coutinho	14 35	34 18	1.283	19,7	25,2	12,8	12,4	39,0	1,0
Vila Cabral	13 18	35 08	1.277	18,6	23,7	13,3	10,4	32,5	4,0
Maniamba	12 46	35 00	1.093	20,3	25,1	13,9	11,2	34,1	5,1

Relative Humidity.

The distribution of relative humidity is fairly regular in the territory of Mozambique. The average annual value varies between 70 and 80% and the monthly average between 65 and 80 per cent, being higher during the warm than during the cool season. It is not seldom that, in a matter of few honrs, the relative humidity rises by 10 or 15 per cent to 90 or 95 per cent, when the wind changes in direction from North to South. Therefore, it is incorrect to classify the weather of the colony of Mozambique as mildly humid, as the normal condition is extremely damp, with occasional extremely dry periods. (Plate 3)

The following table gives the average annual percentages for relative humidity along the coast and in the interior.

TABLE 4. RELATIVE HUMIDITY.

LITTORAL			INTERIOR.		
Localities	Altitude (m.)	Relative Humidity	Localities	Altitude (m.)	Relative Humidity
Lourenço Marques	59m.	74,6%	Namaacha	594m.	69,0%
Quissico	150	74,4	Zimane	-	59,3
Inhambane	14	69,9	Macequece	703	63,4
Beira	7	76,0	Espungabera	1.050	75,5
Quelimane	6	77,6	Tete	111	65,4
Mossuril	15	76,2	Zumbo	335	63,4
Mocímboa da Praia	27	72,7	Ribáuè	530	64,7
			Vila Coutinho	1.283	69,0

Precipitation.

The average annual rainfall along the littoral generally increases from the Southern boundary to the parallel of 17°s, decreasing again to the North of that latitude. It increases with altitude and decreases from the coast to the interior.

Precipitation in the Southern zone is somewhat irregular, but during November and until March 75 per cent of the total annual rainfall is normally received.

The average rain precipitation is annually below 400 mm. in the Alto Limpopo and in the area of Tete, 1,400 mm. along the coast from Beira to Chinde, and exceeds 1,600 mm. in the mountainous regions.

Correlating temperature and rainfall by the formula $I = \frac{P}{T+10}$ a dryness factor is obtained which in the Colony of Mozambique varies from und·r 20 to over 50. The driest zones are the valleys of the Limpopo-Chengane and of the median Zambesi; the least dry are the zones of the Province of Zambesia and of the Alto Pungue, (Plate 3).

Other conclusions are evident from the following table of rain distribution in the southern, central and northern zones.

TABLE 5. PRECIPITATION

Localities, South Zone	South Latitude	Altitude	Precipitation in mm.
	° ′		
Bela Vista	26 20	15	804,8
Lourenço Marques	25 58	59	757,3
Moamba	25 36	110	600,6
Caniçado	24 20	25	605,5
Namaacha	25 59	594	1.001,5
Inhambane	23 53	14	1.019,2
Pafúri	22 26	290	318,3
Vilanculos	22 00	20	1.002,2
Localities, Central Zone			
Nova Sofala	20 09	—	901,2
Espungabera	20 28	1.050	1.451,0
Beira	19 50	7	1.489,7
Vila Gouveia	18 04	661	1.757,8
Quelimane	17 53	6	1.391,4
Tete	16 09	111	528,9
Ile	16 02	531	1.743,4
Zumbo	15 37	335	910,8
Localities, North Zone.			
António Enes	16 13	6	927,2
Nampula	15 07	442	1.012,4
Mossuril	14 57	15	905,6
Ribáuè	14 57	530	1.157,1
Vila Vasco da Gama	14 54	1.153	1.473,8
Vila Cabral	13 18	1.277	1.069,5
Maniamba	12 40	1.093	1.418,6
Mocímboa da Praia	11 19	27	985,1

CLOUDINESS.

The annual value for the cloudiness in the South of the Colony is 4.6. This decreases northwards and towards the interior. The maximum values are in December and the minimum values in June-July.

CLIMATIC ZONES AND SUB-ZONES IN MOZAMBIQUE, AND PREDOMINANT WINDS.

The above climates and direction of winds are shown in the chart, (Plate 4).

1.—*Marginal-Tropical Climate*: including the "Sul do Save," with a hyperthermal marginal zone. The mean annual temperature lies between 22 and 23 °C, with a 4°C variation, 68 and up to 72 per cent average humidity ; rainfall between 750 and 1,000 mm. ; 4.5 average cloudiness ; predominant winds, from S. and E.

This zone includes the sub-zone of the valleys of the Limpopo-Chengane and Incomati, with higher temperature, greater variations, higher humidity, and lower rainfall.

The hot season is from November to March, the cool season from May to August, while the remaining months are transition periods.

2.—*Tropical-Littoral Climate*: including the territory from the Save valley to the Ligonha river, but excluding the elevated regions.

The mean annual temperature is 24-25 °C in the coastal area, with 3 °C deviations ; average humidity 71-74 percent ; average annual precipitation is 1,250 mm.; predominant winds are from South-west ; average cloudiness 3.5.

The rainy season is from November to April and the dry season from May to October ; the transition being very rapid.

In this area it is necessary to consider the *sub-zone of the median Zambesi,* with higher temperatures, less humidity and smaller rainfall.

3.—*Tropical Climate of Monsoon Areas*: including the territories between the Ligonha and Rovuma rivers, but excluding the elevated zones. The mean annual temperature is between 25 and 26 °C, and is constant ; the average rain precipitation is 1,000 mm., 90 per cent of which falls during the N.E. monsoon (October to April) and the remaining 10 per cent during the dry monsoon (May to September) ; average humidity 70-82 per cent with weak deviations ; the average cloudiness is 3.

4.—*Mesothermal Climate of Heights*: including a series of small detached, elevated areas (near or over 1,000 metres above sea-level) such as ; Marávia, Macanga-Angónia, Lago-Metónia, Manica-

Chimoio, Mossurize, Malema-Ribáuè, and the Namúli and Milange mountains.

The mean annual temperature is between 18 to 21 °C ; average humidity, 64 to 74 per cent constantly ; rainfall between 1,000 and 1,500 mm.

These areas are the healthiest in the Colony, and the best indicated for European Colonization.

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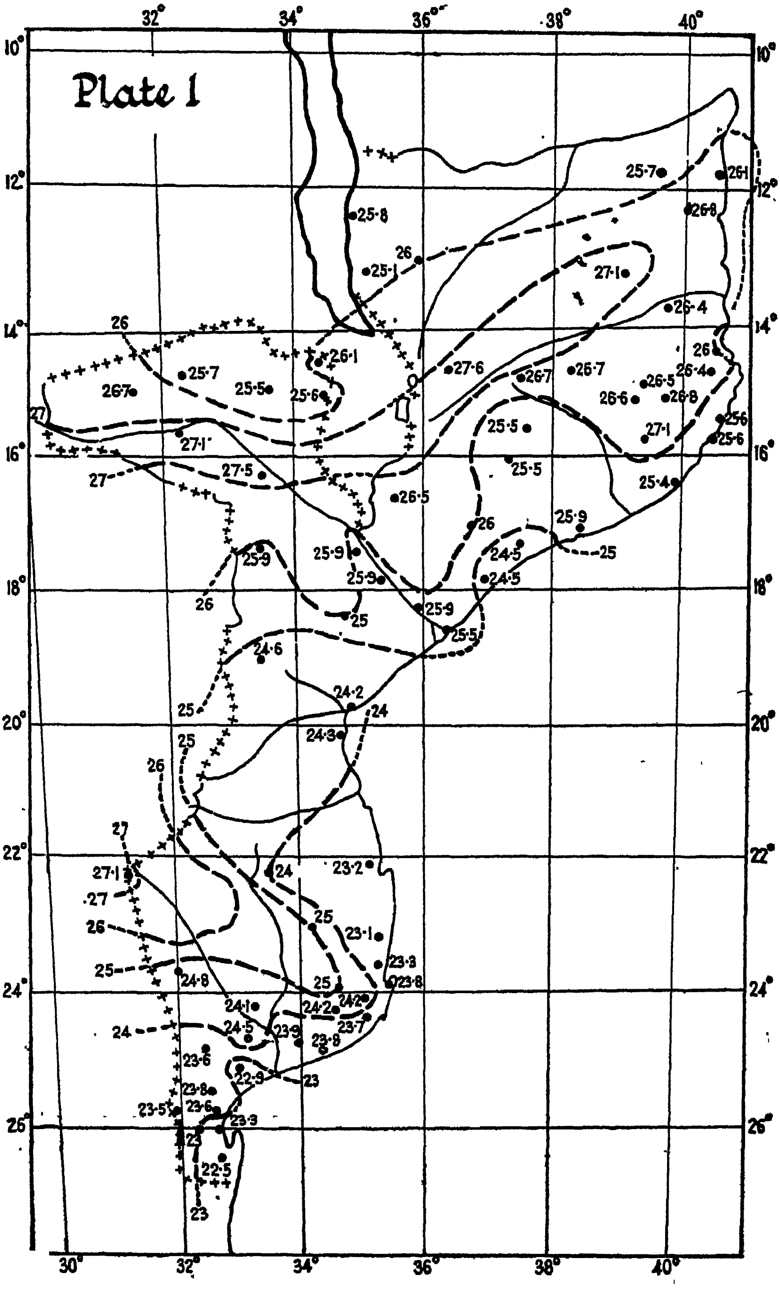
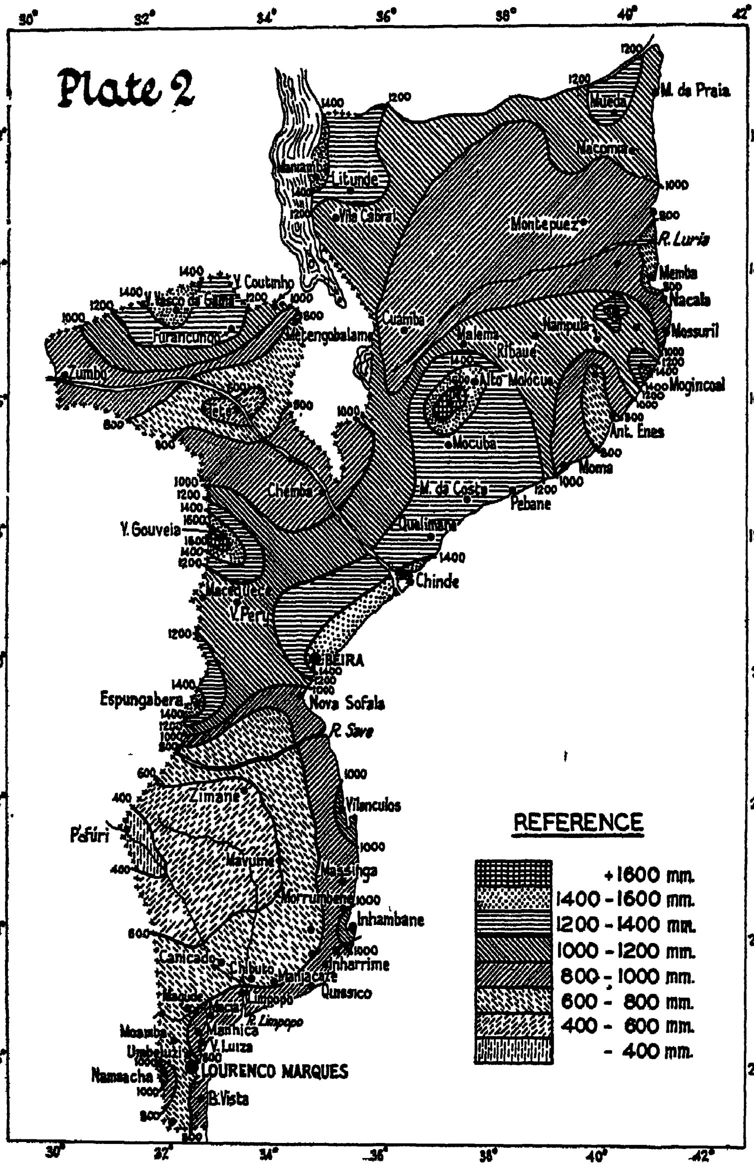
ANNUAL ISOTHERMAL LINES OF MOZAMBIQUE
REDUCED TO SEA LEVEL 1°C/200 M



RAINFALL DISTRIBUTION
ANNUAL AVERAGES



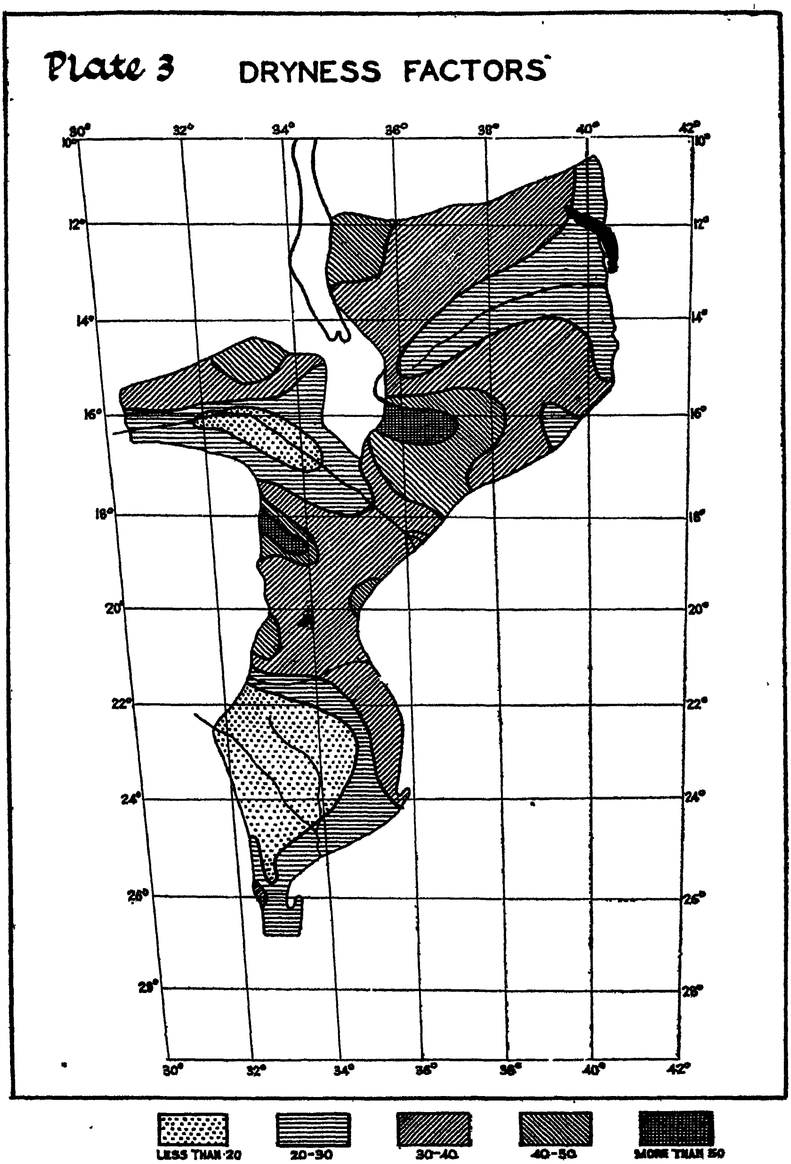
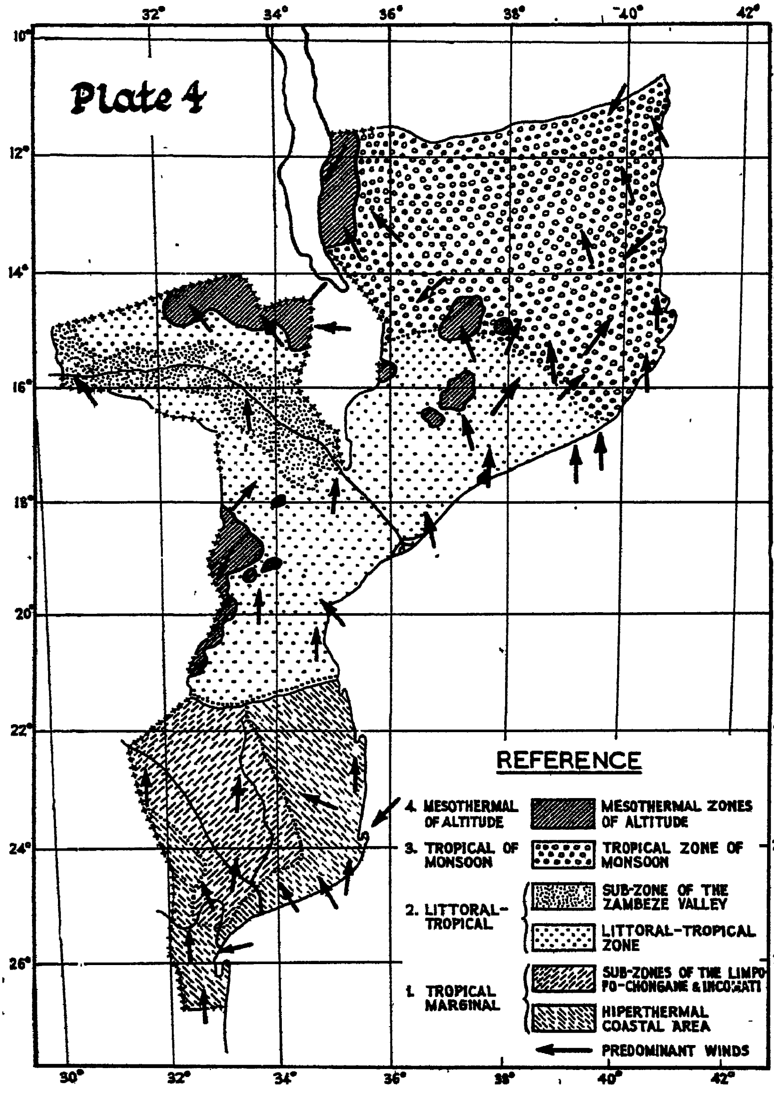


Plate 3 DRYNESS FACTORS
30° 32° 34° 36° 38° 40° 42°
10° 12° 14° 16° 18° 20° 22° 24° 26° 28°
LESS THAN 20
20-30
30-40
40-50
MORE THAN 50

CLIMATIC ZONES & SUB-ZONES IN MOZAMBIQUE

PREDOMINANT WINDS



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DRY MATTER AND PROTEIN OF PASTURES AS AFFECTED BY AMOUNTS AND FORMS OF NITROGEN APPLIED

BY

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Read 1*st July*, 1947.

Introduction.—Numerous papers have been published by members of the Agricultural Advisory Section of African Explosives and Chemical Industries, Limited, on the response of pastures in South Africa to fertiliser application (1937, 1940, 1942, 1945). In all these papers a response to nitrogenous fertilisers has been clearly shown, whilst the effect of phosphatic applications has been shown as an increase in phosphate content of the herbage, without a corresponding increase in bulk or carrying capacity. Potash applications do not appear to have had any marked effect either on the potash content or the bulk of the herbage, but generally induce more even grazing—though this may be due to the chlorine in the potash salt used.

In an attempt to discover the upper limits of the response to nitrogen in both the organic and inorganic forms on "kweek" grass, *Cynodon dactylon* Pers., a fertiliser experiment was put down on this grass in the Turf Research Station of the Frankenwald Botanical Research Station. A similar experiment was put down on a Rhodes grass, *Chloris gayana*, and *Paspalum dilatatum* mixture in a grazing camp, though in the latter experiment the effect of inorganic nitrogen only was considered. In this paper the results obtained over a two year period in the first experiment and over three years in the second are presented.

(1) Fertiliser Experiment on *Cynodon dactylon.*

Technique.—This experiment was put down in the form of a latin square, with plots 5 ft. by 4 ft. in extent, with alleys 18 ins. wide between the plots in both directions. The grass was grown from seed and in order to ensure uniformity of the soil and the removal of rhizomes of other *Cynodon dactylon* strains, the soil to a depth of 12 ins. was dug up, mixed, sieved over a quarter-inch

mesh, and replaced prior to seeding. The seed sown was the Nigel strain used in aerodrome maintenance studies and came from the Dunnottar Aerodrome near Nigel, Transvaal.

It was decided to compare a treatment of 21,160 lb. compost per morgen (5 tons per acre) with soluble nitrogenous fertiliser applications at two rates—namely, 423 lb. and 2,116 lb. sulphate of ammonia per morgen, each in two dressings (200 and 1,000 lb. per acre respectively). All three treatments were given the same phosphate dressing. The treatments and symbols were thus as follows :—

O—No fertiliser or compost.

MP—21,160 lb. compost plus 846 lb. rock phosphate and superphosphate mixture per morgen.

NP—P as above, plus 423 lb. sulphate of ammonia (21·1 % N) per morgen in two equal dressings.

N_5P—P as above plus 2,116 lb. sulphate of ammonia per morgen in two equal dressings.

The first compost dressing was applied on the 4th October, 1944, to the MP plots and dug in immediately. This compost contained 43 % moisture, 22·1 % organic matter and 34·9 % ash. The P_2O_5 content of the moist sample was 0·30 %, N 0·92 % and K_2O 0·31 %. On the 6th October the phosphate dressing was applied to the MP, NP and N_5P plots and the plots were raked. The *Cynodon dactylon* seed was then sown as evenly as possible by hand on the 9th October at the rate of 84·6 lb. per morgen, and the plots were lightly raked and rolled.

Although the rainfall for October, 1944, was apparently normal, the seed germinated unevenly and in consequence the plots were oversown on the 10th November. The plots were lightly raked, sown by hand at the rate of 102 lb. per morgen to the Nigel strain which had been passed through the digestive tracts of sheep, and lightly covered with a sieved mixture of soil and compost. With the help of an occasional watering, a uniform stand was obtained.

Results Obtained.—Originally this experiment formed part of a research project for the M.Sc. degree (Le Roux, 1945) and on 17th January a sample for top and root growth determinations was taken from each plot. The procedure followed was to drive a steel cylinder with an internal diameter of 5 ins. and a depth of 6·5 ins. into the soil until the top was flush with the surface. The soil was then loosened slightly so the cylinder could be revolved,. which broke off the roots penetrating below the 6·5 ins. level. The cylinder was then removed, the soil sample pressed out on to a sieve and the soil removed by means of a spray of water. The plant material was then dried in an oven and subsequently the top growth and roots separated and weighed. The results are shown in the accompanying table, as averages of 4 plots.

TABLE 1.—TOP AND ROOT GROWTH IN *CYNODON DACTYLON* 102 DAYS FROM SEEDING.

Part	Grams combustible dry matter per 19·7 sq. ins.			
	O	MP	NP	N_5P
Tops	1·1	2·7	5·0	10·5
Roots	1·4	2·0	2·7	4·6

The herbage was subsequently cut by hand with sheep shears on the 12th February, i.e. 120 days from seeding. On the 14th February, 1945, the second dressings of sulphate of ammonia were applied to the NP and N_5P plots. The plots were then cut for the second time on 2nd May—199 days from planting. Table 2 shows the yields of dry matter, the nitrogen content of the herbage and the return of nitrogen in pounds per morgen.

TABLE 2.—DRY MATTER AND NITROGEN PRODUCTION ON *CYNODON DACTYLON*. FRANKENWALD, 1944-45

Treatment.	Cutting of 12/2/45.			Cutting of 2/5/45.			Totals		Lb. DM per Lb. N
	Lb. DM per morg.	% N	Lb. N per morg.	Lb. DM per morg.	% N	Lb. N per morg.	Lb. DM per morg.	Lb. N per morg.	
O ...	1,213	1·17	14·2	1,039	1·16	12·1	2,252	26·3	—
MP ...	2,081	1·55	32·3	1,647	1·28	21·1	3,728	53·4	7·6
NP ...	3,949	1·29	50·9	1,977	1·31	25·9	5,926	76·8	41·2
N_5P ...	9,009	1·50	135·1	4,790	1·28	61·3	13,799	196·4	25·9

In the 1945–46 season it was not possible to dig in the compost on the compost treated plots, so it was scattered evenly on the surface of the plots on the 3rd January, 1946, after the first cutting of 28th December, 1945. The rate of application was the same as in the first season, namely, 21,160 lb. per morgen. This compost contained 30·3% organic matter, 37·4% of ash and 32·3% moisture. On a wet basis it contained 0·26% P_2O_5, 0·97% N and 0·15% K_2O.

No phosphate was applied to the plots in the second season and the NP and N_5P plots received only the sulphate of ammonia applications as given in the first season, half on 3rd January, 1946, and the other half on 16th February, 1946. Three cuttings were obtained during the season, the dates being 28th December, 1945, 13th February, 1946, and 26th April, 1946. Table 3 gives the yields of dry matter and nitrogen for the three cuttings.

TABLE 3.—DRY MATTER AND NITROGEN PRODUCTION ON *CYNODON DACTYLON*. FRANKENWALD, 1945-46.

Treatment	Lb. DM per morgen	Average N Content	Lb. N per morgen	% N Recovery	Lb. DM per Lb. N 2 year Average
O	3,404	1·57	53·7	—	—
MP	5,302	1·60	85·4	15·4	8·4
NP	7,334	1·56	113·0	66·6	42·7
N_5P	16,184	1·65	280·0	50·5	27·3

(2) FERTILISER EXPERIMENT ON RHODES GRASS AND *Paspalum dilatatum* MIXTURE.

This experiment was put down on a pasture which was sown to the above mixture in January, 1939. The camp was given 700 lb. nitrophosphate per morgen (11% water-soluble, 13·5% citric-soluble and 15·5% total P_2O_5 and 5% nitrogen, partly in the organic form) in the 1940–41 season, 700 lb. nitrochalk (15·5% N) in the 1941–42 season and 300 lb. sulphate of ammonia per morgen in the 1942–43 season. The sward was very weedy at first but the two grasses soon formed a uniform cover.

In the 1943–44 season an experiment was put down on a portion of the camp in the form of a latin square on plots 1/105·8 morgen in extent. The following treatments were compared :

O—No fertiliser.

NP—529 lb. sulphate of ammonia (21·1% N) and 529 lb. superphosphate (16·5% total P_2O_5) per morgen, both in one dressing in spring.

N_2P—P as above and 1.058 lb. sulphate of ammonia per morgen in two dressings.

N_4P—P as above and 2,116 lb. sulphate of ammonia per morgen in two dressings.

In the case of the N_2P and N_4P dressings the P and one sulphate of ammonia dressing were applied in spring and the second nitrogenous application about mid-summer.

When the grass had reached grazing height, one wire cage enclosing a square yard of pasture was placed in each plot at random and the camp was then grazed by beef steers, followed by working oxen and then horses. The grass on the protected areas was then cut with shears to the height of the grazed pasture outside the cage and weighed immediately. Composite samples from the four plots of each treatment were placed in bottles for moisture determinations, and a second composite sample was taken for chemical analysis. This procedure was followed for each cutting, except that moisture determinations were not made in the 1945–46 season and so the average results from the previous season were used.

In the 1945–46 season beef steers were not used to graze down this experiment but only working oxen and horses. Four cuts were obtained in each of the first two seasons and three only in the third.

Results.—The yields of dry matter per morgen and the yields of dry matter per pound of nitrogen are shown in Table 4.

TABLE 4.—YIELDS OF DRY MATTER ON RHODES AND *PASPALUM DILATATUM*. FRANKENWALD.

Treatment	Yield in lb. Dry Matter per morgen				Average Increase due to Treatment	Lb. DM per lb. N
	1943-44.	1944-45.	1945-46.	Average		
O	5,125	5,045	9,282	6,484	—	—
NP ...	8,141	8,747	15,511	10,800	4,316	38·5
N_2P ...	11,577	9,160	16,856	12,531	6,047	27·0
N_4P ...	14,976	10,870	24,790	16,879	10,395	23·2
Rainfall ...	37·34	28·97	24·94	—	—	—

Table 5 shows the average nitrogen content of the herbage and the yields and recoveries of nitrogen over the three-year period.

TABLE 5.—YIELDS AND RECOVERIES OF NITROGEN ON RHODES GRASS AND *PASPALUM DILATATUM*, FRANKENWALD.

Treatment	Average N Content based on Dry Matter	Average Annual Yield of N in lb. per morgen	Increases due to fertiliser treatment lb. per morgen	Percentage Nitrogen Recovery
O	1·1	69·1	—	—
NP	1·2	126·4	57·3	51·1
N_2P	1·3	155·4	86·3	38·5
N_4P	1·6	275·2	206·1	46·0

DISCUSSION.

(*a*) *Experiment on Cynodon dactylon.*—This experiment shows that all three treatments had a marked effect on the root growth of *Cynodon dactylon*, down to a depth of 6·5 ins., as well as on top growth, and the soluble form of nitrogen produced more root and top growth than nitrogen in the organic form.

The results shown in Table 2 indicate that the nitrogen content of the herbage was higher in the 1945–46 season than in the previous one. This might have been expected for the NP and N_5P treatments but not for the compost treatment. Whereas in the first season the compost was dug in immediately after application, in the second it was simply applied on the surface. From this it appears that

ploughing in compost immediately after it has been spread, though it may be advisable in practice for crops, did not have much effect on the efficiency of the utilisation of the nitrogen by *Cynodon.*

The results show that this coarse type of *Cynodon dactylon,* which grows readily from seed, responds to applications of soluble nitrogenous fertiliser, particularly in the presence of phosphate, and is able to produce up to 8 tons of dry matter per morgen.

The percentage nitrogen recoveries are high for both the sulphate of ammonia treatments and indicate that this grass is more efficient than some others in this respect, at least on this Frankenwald soil type. Although the recoveries are high it is noteworthy that even with the very high sulphate of ammonia treatment, it was not possible to obtain herbage with more than approximately 10·31% crude protein. This is probably due to the sandy nature and poverty of Frankenwald soil, for in all our fertiliser experiments on veld and sown pastures there, we have rarely obtained more than 15% crude protein in the herbage.

(*b*) *Experiment on Rhodes Grass and* Paspalum dilatatum.—It is of interest to note that, on the average, this pasture mixture produced about the same amount of dry matter per morgen as the short, close-growing *Cynodon dactylon* under comparable conditions as regards fertiliser applications. Here again the nitrogen content of the grass is low, considering the amounts of nitrogen applied and the results confirm those of the other experiment, which shows that applications of sulphate of ammonia up to the 2,116 lb. per morgen per annum level bring about large increases in yield of dry matter, and relatively smaller increases in nitrogen content of the grass.

It will be noted that the N_2P treatment in this experiment has given somewhat inconsistent results and the percentage recovery of nitrogen is below that of the heavy fertiliser treatment. There seems to be no obvious explanation for this, as in all seasons the fertiliser treatments on the N_2P and N_4P plots were applied on the same day and under the same conditions. Apart from this the recoveries of nitrogen in the two experiments are similar and indicate that the pasture mixture and the *Cynodon dactylon* are equally efficient in the use of soluble nitrogenous fertilisers.

The yields of dry matter per pound of nitrogen applied are practically the same in both experiments at similar levels of application, indicating that the pasture mixture and the pure species under the conditions of these experiments have practically the same producing power in terms of dry matter yield per pound of nitrogen applied in sulphate of ammonia. In the case of compost dressings on *Cynodon dactylon* the yield of dry matter per pound of nitrogen in compost is about one-fifth of that given by the single dressing of nitrogen in the soluble, inorganic form. Here again the compost applied on the surface gave as good, if not better. results than that ploughed in before planting.

Results in keeping with those given in this paper have recently been reported by the Indian Tea Association Scientific Department (1945). At Chambarai, over a six-year period, sulphate of ammonia gave practically twice the increase obtained from compost and over a two-year period without further treatment gave a higher residual effect. At Gandrapara, over a four-year period, sulphate of ammonia gave more than 2·5 times the increase obtained from compost and over a subsequent four-year period without further treatment, had a residual effect more than twice as great as that obtained from compost. Other experiments gave similar results.

SUMMARY.

This paper summarises the results obtained in a two-year fertiliser experiment on "kweek"—*Cynodon dactylon*—grown from seed, and from a three-year fertiliser experiment on a Rhodes grass and *Paspalam dilatatum* mixture.

In the experiment on "kweek" a compost dressing containing 200 lb. nitrogen per morgen plus phosphate was compared with two sulphate of ammonia plus phosphate treatments containing 89 and 445 lb. nitrogen per morgen respectively.

The results showed that as an average of the two seasons nitrogen in the organic form gave 8·4 lb. dry matter per pound of nitrogen applied, whereas the two inorganic treatments gave yields of 42·7 lb. dry matter for the low dressing of sulphate of ammonia and 27·3 lb. per pound of nitrogen applied for the high inorganic nitrogen treatment. In this experiment the recoveries of nitrogen in the herbage ranged from 15·4% for the compost treatment to 50·5% for the high inorganic nitrogen treatment, and up to 66·6% for the low inorganic nitrogen treatment.

On the Rhodes grass and *Paspalum dilatatum* mixture only inorganic nitrogen treatments were compared at three different levels over a three-year period.

112 lb. nitrogen per morgen in the form of sulphate of ammonia, applied in one dressing, gave an average return of 38·5 lb. dry matter per pound of nitrogen applied and a percentage recovery of nitrogen of 51·1%.

Twice the amount of nitrogen, namely 224 lb. per morgen, in two dressings, gave 27·0 lb. dry matter per pound of nitrogen and 38·5% recovery; while 448 lb. nitrogen per morgen, also in two dressings, gave 23·2 lb. dry matter per pound of nitrogen applied and a recovery of 46%.

A comparison of root and top growth weights in the *Cynodon dactylon* experiment, 102 days after sowing the seed, showed the inorganic nitrogen treatments to have had more marked effects on both top growth and root weights than nitrogen in the form of compost.

The results of all analyses for nitrogen content showed that on this soil type and under the conditions of these experiments, it was not possible to obtain herbage with more than 10·13% of

crude protein, although up to 448 lb. nitrogen per morgen had been applied in a single season and nitrogen recoveries were high.

The effects of the treatments, in general, were thus to increase dry matter production rather than crude protein content in both experiments.

Acknowledgments.—The authors wish to record their thanks to the chemists of the Umbogintwini Factory of African Explosives and Chemical Industries, Limited, for carrying out dry matter and nitrogen determinations.

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THE PARASITISM OF *ALECTRA VOGELII* BENTH. WITH SPECIAL REFERENCE TO THE GERMINATION OF ITS SEEDS.

BY

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Read 2nd July, 1947.

ABSTRACT

Alectra Vogelii Benth. is an angiospermous root-parasite which causes serious damage to leguminous crops in certain areas of the Transvaal and Southern Rhodesia. Its life-history resembles that of the well-known root-parasite *Striga lutea* Lour.

The roots of the host plants exude a substance which is necessary for the germination of the seeds of the parasite. Nearly all the leguminous species tested exuded such an activating substance, whereas the non-leguminous species did not activate germination.

Exposure of the seeds of the parasite to moist and warm conditions before the activating substance is added, enhances the rate of germination. When such pre-exposure forms part of the germination technique, fairly constant results are obtained.

Although the stimulating substance is active even in very minute quantities, it has in concentration, within certain limits, a pronounced effect on germination.

The active substance is thermo-labile. When its solutions are exposed to temperatures of 60° C. and above, they become less active. Solutions of the substance are also inactivated when aged at room temperature, total inactivation occurring within a period of from four to eight days.

It is concluded that the embryo of the parasite probably suffers an avitaminosis, the host roots supplying the missing factor necessary for germination.

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THE EFFECT OF GRAZING AND CUTTING ON *PENTZIA INCANA* DURING DROUGHT

BY

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Read, 2nd July, 1947.

SUMMARY

Experiments have been made at the Veld Reserve, Fauresmith, to ascertain the chemical and morphological effects of cutting and grazing on *Pentzia incana*.

By hand cutting a very stunted bright green plant is produced, whilst grazing produces the usual high bush with sparingly green twigs, the grazed veld, however, does not give a green impression during drought while the cut plots do. The amount of food yielded in May, 1947, at the best time of the season by frequently cut plots, heavily grazed plots, and control plots (cut only once at the beginning of the season) respectively per 5 square yards, was: cut, 654 grams; grazed, 382 grams and control 688 grams (dry).

Of the chemical constituents, protein, fibre, phosphorus and calcium were of particular importance, but apart from the phosphorus there was not much difference in analysis between cut and grazed plants. The cut plants had a high maximum phosphorus content very much earlier in the season than the grazed plots and the maxima for cut and grazed plots were much higher than for the control plots which had their maximum late in the season.

Admitting that the season 1946–47 was unusual, there was a peculiar trend of several constituents in all the samples, perhaps most pronounced in the cut plots. The ash content reached a peak during a drought in January, and again in the moist May. The protein was at its highest in November, at its lowest in January, and showed an increase again in May; rain late in January causing only a short temporary increase. The fibre content was at its highest in January, particularly in cut and grazed samples, and increased again, in spite of good rains, at the end of the season. Carbohydrate and ether extract were at their highest level early in the season, and at their lowest in all the samples at the end of the season. The widest ratio between fibre and carbohydrate was in November, when roughly the ratio was 1 : 3; and protein to carbohydrate ratio about 1 to 2.

At the end of the season the ratio of fibre to carbohydrate was roughly 3 : 4 with the exception of one small plot which was razed and cut and still showed the original proportion of 1 to 3.

The protein to carbohydrate ratio had deteriorated to 1 : 2·6 for the cut, 1 : 3 for a grazed and cut plot, but had scarcely changed for the control and the grazed plot.

With regard to the direct assimilates, drought decreases the photosynthetic activities of all plants, so that for some time no starch is present, even when the water content first improves, but the total absence of starch is the earliest result and is more prolonged in the cut and grazed plants as compared with the control. The latter fact explains the quick deterioration of *Pentzia* veld in the drought.

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A POSSIBLE METHOD FOR INCREASING POLLEN FERTILITY OF SUGAR CANE IN NATAL

BY

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Read 1*st July*, 1947.

ABSTRACT.

Although it has been found (Brett, 1946) that sugar cane in South Africa can set seed, the work of breeding is limited by low pollen fertility. In the course of a routine examination of flowering canes for viable pollen during the years 1944 and 1945, it was noticed that pollen fertility tended to increase as the season advanced. At the beginning of the flowering season viable pollen was found in only a few varieties of cane and these were hardy types for the most part closely derived from *Saccharum spontaneum*. In November or December, however, fertile pollen occurred in a considerably higher proportion of the varieties flowering, including some of those released for commercial cultivation. In some of the varieties which flowered over a long period it was found that viable pollen was not produced until some months after the commencement of flowering. The variety Co. 301, for example, was completely male sterile in July of both 1944 and 1945, whereas by October of both years it had started to produce much fertile pollen and seedlings were raised, using this variety as a male parent. It was thought, therefore, that if during the earlier part of the flowering season canes were subjected to conditions approaching those normally occurring later in the year, fertile pollen might be produced in some varieties that had previously been male sterile, and, in other varieties, the period of pollen fertility might be extended and the number of possible combinations in crossing thereby increased. As the climate of October differs from that of July in having longer days and higher temperatures, and as these would also appear to be the main differences between the winters of tropical countries where the pollen fertility of sugar cane is high and those of sub-tropical countries where it is low, it was to these factors that attention was directed.

METHODS.

In this work it was necessary to use cut canes that were going to flower as sugar cane grown in pots at the Experiment Station had never been known to flower and any attempt at control of temperature and length of day would be both difficult and costly in the field.

A method of preserving cut canes, combining some of the advantages of the Indian and the Hawaiian methods, had been

found (Brett, 1947), and by its use it was possible to keep cut canes that were going to flower in a healthy condition for a long time.

Two separate methods were used in an attempt to increase pollen fertility. In the first the canes were kept in a closed glasshouse during only the warmer part of the day (usually from about 9.00 a.m. till 4.00 p.m.), and kept at other times in a small room artificially heated by an electric radiator of 1,000 watts, the reflector of which had been removed to make the distribution of heat more even. Length of day was increased by leaving an electric light of 150 watts to burn until 8.00 p.m. In order to counterbalance the fall in relative humidity produced by heating the air (which tended to increase the absorption of the somewhat toxic preserving solution by the cut canes), a small flask of water connected by a siphon to a reservoir was kept boiling over the radiator.

In the second method the canes were not removed from the glasshouse. As the heating of the whole glasshouse was unpractical, four infra-red lamps focussed at about the level of the unopened inflorescences were used when the temperature began to fall. As the lamps gave out much light as well as heat, the canes were thus subjected to continuous illumination.

In these experiments the variety Co. 301 was used. Canes used in the first method were cut at two different times; on 10th July, 1946, three canes that were showing the first indications of future flowering were cut (Group I); on 19th July, 1946, however, the inflorescence of one of them was found to be dead. Four new canes, cut with rather longer stalks, were then added (Group II), and at the same time six canes at a stage slightly more advanced towards flowering were cut for use in the second method (Group III). Of the latter, two were subsequently found to have dead inflorescences; it is not thought that this resulted from the experimental conditions, as many canes in the field had been found to have dead embryonic inflorescences, and was possibly the result of the severe drought.

Results.

By the 2nd August, two inflorescences of the canes kept in the glasshouse had begun to protrude. The one was infertile at the time of examination, as shown by the absence of any starch-filled pollen grains. The other tassel, however, had many apparently normal pollen grains and a large number of the anthers were dehiscing. The anthers, however, were yellow or with only a slight purplish tinge instead of the usual purplish colour of fertile anthers in the field. When ten stigmata were examined, three germinating pollen grains were found. Seven tassels collected the previous day from the original field were found to have no starch-filled pollen grains.

The production of fertile pollen increased from day to day until by the 20th August, when all the canes with live tassels were in flower, all were producing normal pollen to a greater or less extent. The inflorescences of Groups I and II apparently produced more viable pollen than those of Group III; all their anthers appeared to dehisce, and the pores opened very widely. If the inflorescences of the first

two groups were tapped in the morning, dense clouds of pollen were released; this had never been observed in the field in Natal though it apparently occurs in tropical countries. The two tassels of Group I, however, did not completely protrude, and the anthers of the one were yellow, whereas those of all the others were purplish at this time.

When eight tassels, growing in the field from which those used in the experiment had been taken, were examined on the following day for pollen fertility, four were found to have no starch-filled pollen grains. Of the remaining four only three showed any dehiscence and of these only one had the majority of its anthers dehiscing.

After the tassels had ripened, the seeds were collected and sown to find the effect of the different treatments upon seed setting.

The number of seedlings from the inflorescences of Group I (31 from 2 inflorescences) seemed rather low in comparison with the amount of viable pollen produced, but this was probably due to the short stalks of the canes in this group, and to the fact that the inflorescences did not protrude fully. The tips of all tassels tended to dry out before the lower portions were ripe and as a result some of the seed was blown away; mixed seed which had been blown off from the inflorescences of Groups I and II produced fifty-one seedlings. The number of seedlings for Group II (297 from 4 inflorescences), would probably have been still higher but for the fact that one of the tassels had been accidentally broken before completely ripe and gave, when sown, only four seedlings. In group III, 4 inflorescences gave 57 seedlings. No numbers of seedlings approaching those of the other tassels in Group II had ever been obtained from inflorescences in the field, and in fact from seed collected at various times from twenty-five tassels of Co. 301 (all of which at the time of anthesis had shown indications of male fertility) an average of less than five seedlings per tassel had been obtained. It has been found, however, that glasshouse conditions at the time of pollination appear to favour seed setting, quite apart from any effect on the formation of viable pollen (Brett, 1947).

Conclusion.

The results indicated that the most favourable treatment for increasing fertility was that in which the canes were cut with rather long stalks and subjected to glasshouse conditions in the day and moved towards evening to a heated room, where the length of day and the relative humidity were artificially increased. The individual effect of these factors has still to be determined. Should this method prove generally applicable, it would be of value in overcoming one of the major difficulties of sugar cane breeding in Natal.

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NOTES ON FOUR SPECIES OF *COLEOPTERA* ATTACKING TURF IN THE EASTERN CAPE PROVINCE.

BY

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Read 2nd July, 1947.

For several years we have been interested in the Arthropod pests of turf, and in 1940 (Omer-Cooper, Whitnall and Fenwick) we presented a paper to this Association dealing with some general aspects of the problem of South African turf in relation to invertebrate pests. Stationed as we are in Grahamstown, most of our studies have dealt with the pests of turf in the Eastern Cape, where white grubs, the larval stages of Lamellicorn beetles, cause much damage to the fairways and greens of golf courses. During the past ten years golf courses at East London, Port Alfred, Port Elizabeth and Mossel Bay have been severely damaged by white grubs, and in each case the damage has been almost identical. The grubs are root feeders and may completely destroy the grass roots just below the surface of the soil. Sometimes large areas of the turf on the greens and fairways are "scalped" and can be picked up and rolled back like a carpet. If the soil beneath this damaged turf is examined, many large white grubs can be found, and these do not differ greatly in size amongst themselves, or from one golf course to another. The turf destroyed on each course is principally composed of *Cynodon dactylon* Pers. and, furthermore, the damage usually appears at the same time of the year at the four different places.

These observations at once suggest that there is a large species of Melolonthid beetle which is common to the coastal veld along the 400 mile strip from Mossel Bay to East London. Furthermore, as no inland golf courses have so far been subjected to such damage, it would appear that this beetle is confined to a rather narrow coastal belt.

One of the most unexpected and interesting facts that has been brought to light by our studies is that no two golf courses are injured by the same species of beetle. Thus along the coastal belt, over a distance of 400 miles, each of four different beetles has assumed the role of a major pest of turf and each of them is mutually exclusive. The insects furthermore belong to two different sub-families and

three different genera of Coleoptera, yet the type of damage which they do is almost identical.

We have been fortunate enough to have bred the adults from the larvae obtained in the field and have secured both males and females of each species. Females of these genera are extremely scarce in collections, and the females of the majority of the known species have never been described.

The nomenclature of all these insects is exceedingly confused and we are much indebted to Dr. A. J. Hesse of the South African Museum, Cape Town, for comparing our specimens with material named by Péringuey, whose nomenclature we are retaining, as until we are able to obtain certain literature not yet available we do not feel justified in changing it. Péringuey's vast work is the only readily available source of information on the South African Scarabaeidae, and we are therefore keeping his designation of species while drawing attention to the changes which are likely to be necessitated by the International Rules of Zoological Nomenclature.

EAST LONDON (East Bank of Golf Course).

Sub-family, Dynastinae. *Pentodontoschema aries* (Fab.) Péringuey, 1902, pp. 527–528.

The correct name of this insect is difficult to ascertain. Arrow, 1937, p. 33, considers that the species described by Péringuey is not the same as that described by Fabricius, 1781, App. p. 495; 1787, I. p. 7, and states that it has been named *P. caper* by Prell. We have not been able to read the original description as our copy of the Species Insectorum lacks the appendix, which is not mentioned by Hagen, 1862, p. 220. This reference is however given by Gmelin, 1788, p. 1529, and Schönherr, 1806, p. 18, whose full citations of the literature are most useful. Fabricius, 1792, p. 19, says "*Habitat ad Cap. Bon. Spei Dom. Prof. Vahl. Faemina Sc. Satyri observante Olivier an rite?*" The Fabrician species *S. satyri* and *S. syrichtus* with which his *S. aries* are identified by later authors, are American insects. Horn, 1926, p. 125, informs us that Vahl's collection is in the museum at Copenhagen, so that it may yet be possible to unravel the tangle and establish the name of the insect with certainty.

It is a large black beetle rather like a Scarab and appears to be confined to the Cape Province where Péringuey tells us it occurs at Cape Town, Stellenbosch, Paarl, Malmesbury, Knysna, Fraserburg and Uniondale, "walking with difficulty on grassy plots after summer rains". It is most destructive at times, its larvae scalping the sod in the same manner as the Melolonthid beetles of Port Alfred, Humewood and Mossel Bay.

Little is as yet known of its habits and we have not completed our study of its life-history. Third instar larvae collected in May, 1941, made cells in the soil and lay motionless in them until the early summer of 1941–42 when they pupated. The pupal stage lasted from 26–41 days in our insectary. It is therefore probable

that the life-cycle takes at least two years to complete. The newly emerged beetles are a dark red-brown but rapidly become black. They tunnel upwards shortly after they are free from the pupa case and soon reach the surface where they walk about seeking for companionship both by day and by night. The sexes are almost indistinguishable and neither have been seen to fly.

It is interesting to note that a near relative of this insect, *P. nireus* Burm., was one of the first recorded insect pests of South Africa, being included, as a pest of wheat, in Miss Ormerod's book in 1889, pp. 10–11. It was described by O. E. Jansen as *Pentodon nireus* Burm. from specimens sent to Eleanor Ormerod by one or both of her correspondents, the " President of the Eastern Province Natural History Society of the Cape Colony", Mr. Bairstow, and the " Lady Curator of the Albany Museum ", Miss Glanville.

It is somewhat remarkable that an insect so widely ranged and capable of such destruction should not have done serious damage in many places, but as a pest of turf it has so far made its presence known only at one golf course. It is probable that in course of time it will make its way to other large areas of turf.

Surface applications of lead arsenate have proved successful in controlling this pest.

PORT ALFRED (Royal Golf Club).

Sub-family, Melolonthinae. *Macrophylla maritima* Burm. Péringuey, 1908, pp. 129–130.

Péringuey has muddled things up in a dreadful way and von Dalla Torre, 1912–13, p. 303, seems to have been hypnotised by him and to have made things worse. A careful study of the literature would have prevented such errors but Péringuey perhaps did not possess the works of " the illustrious Schönherr whose work is or should be in the hand of every person who calls himself an Entomologist". However this may be, he did not study Hope's manual with sufficient care. Whatever insect, Hope, 1837, was describing when he drew up his description of the genus *Macrophylla* it is quite certain that he believed himself to be dealing with *Melolontha longicornis* of Fabricius, despite his *lapsus calami* (or the printer's error) on p. 103, for on pp. 40 and 70 he makes his intention perfectly clear. Fabricius, 1787, p. 28, says of *M. longicornis* " *Antennarum clava lamellis tribus porrectis.*" It appears to be the custom to regard the generic names in the Dejean catalogues as invalid, as no description is given, or *Aegostheta* Dejean, 1833, would have precedence. Erichson, 1847, p. 654, in a footnote discusses this matter and revives Dejean's genus with a different spelling *Aegostetha*. Unfortunately, both these genera definitely contain the *M. longicornis* of Fabricius, so that although it might be possible to make a case against Hope's *Macrophylla* and make it a synonym of *Aegostheta* Dejean, it does not help us with Péringuey's beetles. To make matters worse the name *maritima* Cast. (?—mari-

tima Burm.) is correctly applied to a beetle which Péringuey would have placed in the genus *Aegostheta* Blanchard, so that the Port Alfred beetle has no name at all, generic or specific.

Péringuey can be forgiven for muddling the nomenclature, for he could not get all the necessary literature, but we find it hard to forgive him for omitting the names of the collectors who provided the material for his somewhat pretentious work. In this case he gives the locality as Grahamstown. This is, we believe, incorrect. "*M. maritima*" is a large blundering cockchafer, which flies furiously to light in the evening, and cannot be ignored. Wherever it occurs it is most noticeable. We have searched for it for ten years but have neither seen nor heard of a single specimen in the Grahamstown area. We believe it to be confined to a narrow strip of coast, not more than a mile or two in width, stretching from the Great Fish River to the west bank of the Bushmans River. We have personally taken it in numbers at Kleinemonde, Port Alfred, Kasouga and Boesmansriviermond.

It is a large handsome cochckafer which emerges during the summer rains from December to March. Only the male beetles fly and they appear on the wing after sunset. They have large antler-like antennae, with five lamellae forming the club, and, as they are attracted to light, many may be caught in this way. The massive females, with small antennae, do not fly, but after sunset, and particularly after rain has fallen, burrow out of the ground and wander ponderously over the turf for a short time. After fertilisation they burrow back into the ground. The life-history of this beetle is not known, but we believe that it is similar to that of the beetle from Humewood.

Previous to 1940 the grubs of this beetle did much damage to the turf on the course of the Royal Port Alfred Golf Club but subsequently a remarkable natural control of beetles and white grubs took place. From time to time in 1936 and following years large numbers of a bird, the Hadeda Ibis (*Hagedashia hagedash hagedash*) were noticed on the fairways of the Golf Course. The birds seemed to be particularly fond of the 9th fairway and were often seen feeding, pulling the food out of the ground with their beaks. This particular fairway was one which periodically suffered much white grub damage, and a close inspection of the Hadedas' operations revealed the fact that the birds were feeding on large white grubs, which were near the surface. When the area in which the birds were feeding was carefully examined, it was found to have numerous holes which had been made in the sandy soil by the long beaks of the Hadedas, and remains of white grubs were everywhere to be seen. Some of the grubs were not swallowed whole, but the birds appeared to squeeze out those portions they wanted and would reject the hard yellow head and portions of the integument.

In 1943 it was noted that the Hadedas, once present on the Port Alfred course in their scores, were no longer frequenting the

fairways, but had migrated to the Port Alfred aerodrome. Here they were considered a menace to aircraft when landing and taking off, and the Hadedas were being shot. Subsequently the gizzard of one of these birds was examined. The diet appeared to consist almost entirely of beetles and grubs, for the gizzard contained the remains of many of these.

PORT ELIZABETH (Humewood).

Sub-family. Melolonthinae. *Macrophylla pubens* Péringuey, 1908, p. 129.

The validity of nomenclature of the genus has already been discussed and the specific name is unlikely to be assailed.

This beetle has been studied in detail so that its structure, life history and habits are fairly well known. We have taken males and females from the Humewood Golf Course while males have also been taken at Schoenmaakerskop. Males and females are slightly smaller than the corresponding sexes of the Port Alfred beetle, but, as these two Melolonthids are closely related, their habits are very similar.

Beetles may appear above ground towards the end of December and continue to emerge until the end of March, the adult stage thus lasting about three months. The appearance of beetles above ground is greatly influenced by rainfall, for, almost immediately after rain, large numbers of beetles tunnel to the surface. The beetles are not active during the day, but appear above ground just after sunset and males have been taken up to midnight. Only the males fly. They have large antler-like antennae, and, as they are attracted to light, many may be caught at light traps. The female beetle is bigger than the male and has a more robust appearance. In contrast to the male the antennal club is small. Female beetles are not readily observed, and we have never seen them fly. Just after sunset, however, and more particularly after rains have fallen, the females burrow out of the ground and come to the surface of the greens and fairways for a short time. On the smooth mown greens the females can be readily seen, but in the natural vegetation of the "rough", it is most difficult to find the non-flying female, the description of which has not yet been published. When the female has burrowed out of the ground she may wander aimlessly over the turf for a short distance and then start burrowing into the soil again. She allows her posterior end to protrude and it is in this position that the males find her. Flying males are apparently attracted to the female by scent, for if a female has taken up the position described above, it is not long before she is surrounded by excited males and the most dashing has copulated with her. Sometimes when the males are slow to approach, the female raises the tip of the abdomen and averts the cloaca, which pulsates and presumably, emits an odour which is strongly attractive to males.

After fertilisation the female sluggishly burrows back into the soil to lay eggs. The average number of eggs laid by a female beetle

is 45, as we have often found numbers approximating this next to females in natural conditions. The largest number of eggs laid by a female in the insectary was 64. The eggs take about five weeks to hatch. The first larval instar lasts about five months, the second instar about two months, and the third instar about eleven months. The prepupal stage lasts about a month, while the pupal stage lasts approximately one month also. The time taken to complete the life-cycle is thus about two years.

Adults emerge every year, but major flights of beetles occur every other year. Large third instar grubs can be found in the soil throughout each year. It is also interesting to note that the eggs are generally laid deep in the soil, as far down as 3 or 4 ft. Most of the damage to the turf seems to occur during the short second instar, and the brief feeding period of the third instar. Both these instars are found near the surface of the turf, at this time of year. The prepupal and pupal stages are passed deep in the soil, again as far down as 3 or 4 ft.

This beetle pest has caused severe damage to fairways and greens of the Humewood Golf Course, and in 1942 extensive applications of lead arsenate were made to combat the pest. The lead arsenate was applied at the rate of 1 oz. per sq. yd. to the surface of the turf and this treatment appears to have afforded protection for four years, as no grub damage has been noticeable for that period.

MOSSEL BAY.

Sub-family, Melolonthinae. *Aegosthetha* sp.

This species is near to *A. ciliata* Herbst. although, according to A. J. Hesse, it differs from insects which are in the Péringeuy collection under the name *Aegosthetha ciliata* Herbst. *Aegostheta* was a name created by Dejean, without description, in his catalogue of 1833, p. 159, and as the only valid species it contained was *S. longicornis* Fabr., which was nominated by Hope, 1837, pp. 40 and 70, as the type of his genus, it becomes a synonym of *Macrophylla* Hope. It seems probable that our species will turn out to be the true *Macrophylla maritima* Cast., and so make confusion worse confounded.

The biology of this insect seems to be unknown and the female has not yet been described. The beetles emerge in the summer after rain and the males, which are easily distinguished by their long antennae with three lamellae forming the club, fly readily during the day-time. We have seen them on the wing from 10 a.m. to 4 p.m., after which they disappear into the ground. The heavy females, easily distinguished from the males by the small antennal club, do not fly, but crawl about slowly until fertilised, when they at once dig a burrow and descend into the soil, often accompanied by one or more males. The total period of surface life seems to be very short, for as far as we have been able to ascertain they are only above ground for two or three days each year.

The third instar grubs have been collected and from these both male and female beetles have been obtained. The larvae lived for some months before pupating and the pupal stage lasted one month. This suggests that, as third instar grubs are to be found in summer, this species, like the other turf beetles described, has a two year life-cycle.

No concerted control measures have yet been attempted at Mossel Bay, so that at times the golf course suffers considerable damage.

It is interesting to record that we have taken the males of a nearly related species in some numbers, during the day, after rain, in a limited locality on the road between Port Elizabeth and Addo. So far, however, these insects have not made their way to any golf courses or other areas of turf in that district.

SUMMARY.

The golf courses at Mossel Bay, (Humewood) Port Elizabeth, Port Alfred and at East London have all experienced severe damage to turf caused by root-feeding white grubs. Each golf course has its own particular beetle pest and although the habits of the pests differ, the type of damage they cause is almost the same.

The correct identity of the beetles must for the time being remain obscure. All four beetles have, however, assumed the role of major pests of turf, and yet in two cases the females of the species are new to science. This is no doubt due to their habits, for the females do not fly and are not easily detected in natural vegetation. On smooth-mown greens, however, the females are more readily found.

Only one of the beetles, *Macrophylla pubens* Per., from Humewood, has been studied in detail and in this case the life-cycle takes about two years for completion.

Effective control of the white grubs has been obtained at Port Elizabeth and East London by applying lead arsenate to the surfaces of fairways and greens. At Port Alfred, a natural control took place, where large numbers of a bird, the Hadeda, saved the turf by devouring the grubs when they were near the surface.

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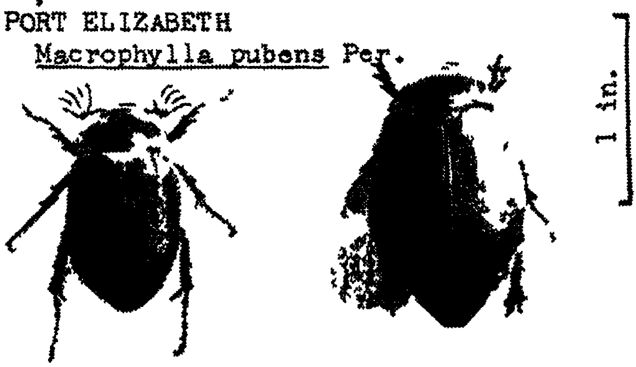
ILLUSTRATIONS.

FIG. 1.—FOUR BEETLE PESTS OF TURF FROM THE EASTERN CAPE PROVINCE.

FIG. 2.—PORTION OF 16TH FAIRWAY AT HUMEWOOD. An example of the damage done by the larvae, white grubs, of the beetle *Macrophylla pubens* Per. The grubs are root feeders and have completely destroyed the grass roots. Large sections of turf can be picked up like a carpet, and if the soil beneath is examined, grubs will be found.

MOSSEL BAY
Aegostetha sp.

PORT ELIZABETH
Macrophylla pubens Per.



PORT ALFRED
Macrophylla maritima Bur.

EAST LONDON
Pentodontoschema aries Fabr.

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THE BIOLOGY OF *ANOMALA VETULA* WIED AN ARTHROPOD PEST OF TURF IN SOUTH AFRICA

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Introduction.—For the past nine years, the Zoology Department of Rhodes University College, in co-operation with African Explosives & Chemical Industries Ltd., has been studying entomological problems relating to turf on the golf courses along the coastal belt of the Eastern Cape Province. At Mossel Bay, Humewood (Port Elizabeth), Port Alfred and East London, vast damage has been done to the greens and fairways by "white grubs," the larvae of Scarabaeidae. It would appear that these beetles have been present for many years, but it was only when large areas of the natural veld were converted into fairways, with a more or less uniform cover of grass, with *Cynodon dactylon* Pers. predominating, that conditions were created which favoured the development of the beetles.

On 25/11/43 the aerodrome at 42 Air School, Port Elizabeth, was visited. It had a good cover of *C. dactylon*, and on the surface all appeared well. There was, however, much evidence of the activities of insectivorous moles, and experience had shown that this was generally indicative of the presence of insects, beneficial or otherwise, in the soil. Excavations were made and under an area of turf 2 ft. x 3 ft., forty-eight "white grubs" were found. The beetle was identified as *Anomala vetula* Wied. In view of the limited knowledge of "white grubs" which we have in South Africa, it was decided that a detailed study should be made of this beetle, in order that its relation to turf might be better understood. The study of the life-history is confined to specimens collected at 42 Air School, Port Elizabeth.

1. *The Egg* (Fig. 1).

The newly laid eggs are fairly uniform in appearance and size. They are white, oval, and have a smooth surface. It is characteristic of the eggs of Lamellicornia, that the shape and size change during growth after deposition (Imms, 1934, p. 532). The increase in size is dependent on the absorption of moisture from the soil. Twenty-five eggs that were five days old, had a mean length of 1.9 mm. and a mean diameter of 1.4 mm. The appearance of the egg undergoes striking changes five days after deposition ; it becomes pearly white. After 7 days the mean length had increased to 2.3 mm. and the mean diameter to 1.6 mm. After this stage the increase in width is greater in proportion to the increase in length, so that

the egg loses its elliptical shape, and becomes rounded. The maximum size was reached in twelve days. The mean length was 2.6 mm., and the mean diameter 2.2 mm. The largest egg was 2.7 mm. long and 2.3 mm. broad.

The eggs are laid singly, as in *Phyllopertha horticola* L. and *Anomala aenea* Geer. (Rittershaus, 1927, p. 380). The secretion from the colleterial glands of the female makes the surface of the eggs sticky for about twelve days after deposition, so that sand particles adhere to the eggs, but it is not sufficient to cause a ball of earth to form round them. A similar condition occurs in *Popillia japonica* Newm. (Thomas, 1925, p. 359), and in *Anomala cuprea* Hope (Yuasa and Endo, 1938).

1. *Embryonic Development.*

The eggs retain their homogeneous appearance for twelve days. As in other Scarabaeidae the form of the developing embryo can be seen through the chorion (Hayes, 1929, p. 48). By comparison with descriptions of the embryo of other species, the chorion appears to be less transparent. It remains strong throughout development.

2. *Hatching.*

Just before hatching the thorax and posterior end of the larva swell. The chorion is stretched round the larva, so that the egg assumes an irregular shape. The mouth-parts, particularly the mandibles, legs, hatching spines and hairs on the body, can be seen, owing to their darker sclerotisation. Careful observation reveals continuous movement of the body.

Muscular contraction of the larva with the aid of the hatching spines causes the chorion to rupture. The importance of hatching spines in the splitting of the egg-membrane is dealt with by Rittershaus, 1927, p. 391, in *P. horticola* and *A. aenea.* Movements of the larva cause the curvature of the dorsal surface to become more pronounced ; this results in the rupture of the chorion. It occurred almost invariably in the position of the hatching spines and was always transverse. The split is small at first, but further muscular activity of the larva causes the split to continue down the sides of the body until the embryo is able to emerge. The dorsal surface of the middle of the body usually protrudes first, the head and anal segments remaining within the egg. Waves of movement continue to pass along the embryo, almost unceasingly. This movement is assisted by pressure of the head and posterior anal segments against the egg ; the legs do not appear to assist in the hatching process. The mandibles and lower region of the head appear occasionally ; eventually the anterior region of the body is extricated. Pieces of the chorion may adhere to the posterior region of the grub for several days. Towards the end of hatching, the grub becomes quiescent, and only movement of the mandibles and maxillae occurs. The hatching process takes about three hours. This is undoubtedly longer than is normally required when the grub is surrounded by earth.

II The Larval Instars (Fig. 2).

1. *The First Instar Larvae.*

The newly hatched grub is delicate and pale. The thorax and abdomen are white; the reddish-brown asperities and hairs give it a superficial ferruginous appearance. The hatching spines are conspicuous. The spiracles are light brown. The head-capsule is soft and rugose. The length of the head-capsule, from the fronto-clypeal suture to the posterior margin, varied from 0.7 mm.— 1.1 mm. with a mean of 0.96 mm. for seventeen specimens ; the width below the bases of the antennae varied from 1.5 mm.—1.8 mm. with a mean of 1.65 mm. The tips of the mandibles and their articulation points are a dark reddish-brown. The tip of the galea and lacinia, and the terminal segment of the antennae are lightly sclerotised. The hypopharyngeal sclerome is almost black. The legs have a transparent appearance, the coxal joint is slightly ringed.

The grub soon becomes active and assumes a darker colour. Feeding usually starts 1-2 days after eclosion. This causes the posterior region of the abdomen to become a light blue-grey. First instar grubs are active crawlers. They do not travel far, but radiate out a short distance from where the eggs are laid. They feed on small roots and soil, which is sufficient nourishment during this instar.

At the end of each larval instar, ecdysis is accompanied by a splitting of the head-capsule along the epicranial suture. The split is continued along the dorsal surface of the body to the end of the abdomen. The thorax, head and finally the abdomen are extricated.

2. *The Second Instar Larva.* The length of the head-capsule varied from 1.2 mm.—1.9 mm. with a mean of 1.53 mm. for thirty-six specimens ; the width varied from 2.4 mm.—2.8 mm. with a mean of 2.66 mm.

Second instar larvae are the most active of the three instars. They have carnivorous tendencies, as have larvae of *Anomala orientalis* Waterh. (Britton, 1926, p. 541). In *A. vetula* most of the feeding is done in this instar. The grubs are usually found 6-9 inches below the surface of the ground, in the grass roots, where they are surrounded by an abundant food supply. If placed on top of the soil, they burrowed down rapidly using the mandibles and the first two pairs of legs. Unlike third instar larvae, they were seldom found inactive in cells at the bottom of the breeding jar, unless the soil was very dry. The larvae construct earthen cells in the soil. In the glass breeding jars the movements of the larvae could be clearly observed, when these cells were near the glass. The cells are large enough to allow the larvae to turn in them. The walls are made smooth by pressure of the body. They usually lie on the dorsal surface with the head and last abdominal segments close together. The larvae of *P. japonica* form similar cells (Smith and Hadley, 1926, p. 19). When the larva advances, the mandibles and the first pair of legs scrape away the earth in front of it. The loosened earth is pushed backwards and towards the ventral surface of the grub.

This is accompanied by continuous waves of contraction, which pass along the dorsal surface of the grub. In this way no passages are left as the larva moves through the soil.

3. The Third Instar Larva.

(a) *The Third Stage Larva.*

The length of the head-capsule varied from 2.3 mm.—3.4 mm., with a mean of 2.71 mm. for thirty specimens; the width varied from 3.8 mm.—5.0 mm., with a mean of 4.41mm. Third instar larvae usually stop eating after three or four months. Towards the end of the third stage, each larva constructs an oval earthen cell. These are slightly larger than the grubs and have smooth, firm walls. During this period the grubs are inactive; fat accumulation commences.

(b) *The Prepupa.*

There is no ecdysis between the third larval and the prepupal stages. Imms, 1934, p. 198, states that the prepupa represents a greatly abbreviated instar, during which an ecdysis has been suppressed.

The prepupal stage is recognised by the white appearance of the body, due to the contents of the alimentary canal having been voided, and the deposition of a subdermal layer of fat. During the prepupal stage the gradual change from larva to pupa occurs. The abdomen becomes shorter and wrinkled. The last 1-2 segments of the larval integument become folded under the ventral surface of the contracted prepupa. The wings and elytra become everted, and lie outside the body, but beneath the larval integument. The legs become smaller, and only extend as far as the trochanter of the larval integument. As development proceeds, the darker colour of the pupa can be seen through the tightly stretched larval integument. The genitalia appear on the ventral surface, at the apex of the abdomen.

When the pupa is ready to emerge it becomes increasingly restless. There are, however, long intervals of quiescence. Immediately before ecdysis, waves of contraction pass along the pupa; they exert pressure on the larval integument, and cause it to split. The first rupture occurs in the mid-dorsal line, in the region of the first abdominal segment. It is continued anteriorly along the epicranial suture, and posteriorly as far as the seventh segment. The abdomen is extricated before the head.

III. The Pupa (Fig 3.).

The freshly emerged pupa lies on its ventral surface, enveloped in the integument of the third larval instar and thus does not come into contact with the soil. When the integument of the pupa has hardened, the pupa turns on its dorsal surface and rests on the chitinous arc-shaped ridges of the terga. It is generally motionless, but if disturbed, it may wriggle out of the larval skin. It then lies next to it in the earthern cell.

Immediately after emergence, the pupa is dull yellow ; later it becomes darker. The dorsal arc-shaped ridges of the abdomen, and the spiracles, are conspicuous, being the only strong chitinisations of the soft pupal skin. It is thin, so that shortly before emergence the imago can be seen through the pupal integument. The first pigmentation appears in the eyes, which are large and black. The dark colour of the head, in particular that of the eyes and clypeus, the bi-dentate form of the anterior tibiae, the pro- and metathorax are prominent features. The abdomen of the adult is shorter than that of the pupa, so that there is a space at the end of the pupa before emergence.

IV. The Imago (Fig. 4.).

1. *Emergence.*

The pupal integument is shed in fragments. The first split usually occurs along the mid-dorsal line of the thorax. The integument often splits across at the base of the head and legs, due to their jerking movements, and remains of the pupal integument adhere to them for several days. They are eventually freed by rubbing against the surrounding soil. By a series of movements, the elytra and wings are extricated ; the integument covering these does not usually split. In the freshly emerged imago, the wings are stretched out and only when they have hardened are they withdrawn under the elytra. The abdomen is extricated by alternate contraction and expansion assisted by movement of the legs. The adults remain in the pupal cells for a few days until the chitin has hardened and the beetle attained the normal colour.

The number of males collected in the field is greatly in excess of the number of females. 19/1/44, 42 Air School, Port Elizabeth, 54♂♂, 3♀♀ ; Jan. 1945, Kleinemonde, 37♂♂, 1♀ ; 8/1/45, Golf Course, East London, 200♂♂ ; 17/1/45, Grahamstown, 77♂♂, 4♀♀ ; 19/1/45, Golf Course, Port Alfred, 23♂♂, 1♀. The number of males to females is thus in the ratio of 43 : 1. In the laboratory the sexes emerged in equal numbers. In the field the females burrow back into the soil after copulation, which accounts for the greater number of males collected.

2. *Habits.*

The adults are crepuscular. During the day they remain about six inches below the surface of the ground and only appear above ground shortly after sunset, for about two hours. In the laboratory, males and females have been observed emerging at approximately the same hour as those in the field. They were very active. Both males and females returned to the soil several times during the evening. Occasionally some remained on the surface until the following morning. If adults were put in a jar without soil they continued to be active all night, but became quieter during the day. Meunier, 1928, p. 111, states that the swarming instinct in Lamellicornia is awakened by twilight, and that swarming occurs at a certain degree of darkness. Both males and females fly. The flights,

however, are of short duration. They are not attracted to light. They have not been observed to feed. Destruction caused by other adult Rutelinae, particularly those of *P. japonica* and *P. horticola* has been severe (Smith and Hadley, 1926, p. 25 and p. 27).

3. *Copulation.*

Males are able to copulate immediately they emerge from the pupal cell. Almost as soon as the female emerges from the ground she is surrounded by a number of males. As many as fifteen males have been observed round one female. Both sexes have a characteristic pungent odour, which is stronger during the period of activity in the evening than during the day. Presumably the male is attracted to the female by a special scent as in a number of other Lamellicornia (Rittershaus, 1927, p. 378).

The males are gregarious. Those which are unsuccessful in finding a female, congregate in clusters of a dozen or more, and crawl up long grass blades, or stems of flowers. In the evening when the beetles emerge, this habit of the males is very striking. They remain motionless on the grass blades, or crawl actively up and down. In the latter case they usually fly off after a short while in search of a female. This may be repeated several times. Rittershaus, 1927, p. 378 and p. 400, describes a similar habit in *P. horticola* and *A. aenea.*

The female usually attempts to escape from the males while they try to climb on to her back. At first the male lies almost directly above the female, maintaining that position by grasping the body of the female with the two front pairs of legs. In this position the female usually crawls around with the male on her back. In order to take up the position for copulation, the male moves further back. The first pair of legs grasps the female between the prothorax and elytra, the second pair around the abdomen, while the third pair trails on the ground. Copulation lasts for several minutes. A number of males may copulate with one female. In the laboratory a male was observed to copulate with four different females in one evening. Repeated fertilisation does not appear to be necessary. One female, fertilised once, and then isolated, laid a total of twenty-six eggs in six batches over a period of fourteen days ; all the eggs were fertile.

4. *Oviposition.*

After copulation the female returns to the soil. During the time of maximum emergence, holes in the ground from which the beetles emerged, were numerous. Sometimes these holes are used again when the beetles return to the soil. The female is sometimes followed by the male. The beetles burrow into the ground using the front tibiae. and with the aid of up-and-down movement of the head.

In the laboratory the period between copulation and oviposition varied from 3-8 days, but eggs were usually laid five days after copulation. Females which had not copulated were observed to lay sterile eggs 24-31 days after emergence. The maximum number of eggs laid in captivity by one female was thirty-five, extending over

a period of twenty days. This is the longest time over which egg-laying occurred. In one instance thirty-four eggs were laid by one female over a period of sixteen days.

V. Food Habits of the Larvae.

The larvae are similar to other Scarabaeidae in that they are root feeders. They have been collected from turf, but have not been observed to damage crops. A number of species of the sub-family Rutelinae are injurious to turf as well as to crops, in the larval stage. The presence of forty-eight larvae of *A. vetula* within an area of 2 ft. by 3 ft., on the aerodrome at 42 Air School, Port Elizabeth, 25/11/43, suggested that this species might be a serious pest of turf. Observations made in this area, however, do not indicate that the larvae have caused serious damage to the turf. A possible reason for for this is that they confine their attacks to small roots, a small amount of feeding extending over a long larval period. The presence of larvae in the turf is indicated by soft spongy areas, caused by the burrowing of the grubs a few inches below the surface of the ground In dry seasons these batches can be recognised by the brown colour of the grass.

In the laboratory the larvae were fed on fresh grass roots, which were planted in the jars of soil. Larvae were also fed on finely ground "Taystee Nuts," placed in small cells in the soil. Newly hatched grubs were placed directly on these, and covered with soil. First and early second instar larvae were kept successfully on a diet of "Taystee Nuts" only. During later development it was necessary to supplement this food supply with grass roots.

VI. Depths at which the Instars are found.

The entire life-history, except the adult stage, is passed within one foot of the surface of the ground. The adults appear above ground for about two of the twenty-four months which are normally required for the completion of the life-cycle.

The females burrow into the soil to a depth of six inches, where the eggs are laid. In very hard dry soil eggs have been found two inches below the surface. First and second instar larvae are found in the root system of the grass, within 6-9 inches of the surface of the ground. Towards the end of the second instar, the grubs descend a few inches, the third instar, including the prepupal stage, and the pupae, occurring 9-12 inches deep. The imagines pass most of their lives within 4-6 inches of the surface, except for a short period at twilight each night.

In the winter of the first year of the life-cycle *A. vetula* occurs in the field as second instar larvae 6-9 inches deep. In the second winter third instar larvae descend to 9-12 inches. They do not return to the surface in summer to resume feeding, but pupate at the depth to which they descended as third instar larvae. The depth to which larvae descend in the soil varies greatly in different species of Scarabaeidae. Pupation occurs at the deepest level to which a species

descends, unless after hibernation the larvae return to the surface to resume feeding before pupation, in which case pupation occurs a few inches below the surface. Species of the tribe Anomalini do not descend deep into the soil.

VII Duration of the Life-cycle (Diag. 1.).

A. vetula normally requires two years for the completion of the life-cycle. It extends into three calendar years, as eggs which are laid at the beginning of one year, transform into adults at the beginning of the next year but one. The two life-cycles run concurrently, so that there is an emergence of beetles towards the end and at the beginning of each year. A small percentage of the larvae may fail to transform into pupae towards the end of the second year of the life-cycle. They continue through the following year as prepupae, pupate about November, and emerge as adults at the beginning of the next year, thus completing a three year life-cycle.

Adults which were collected on the aerodrome of 42 Air School, Port Elizabeth, on 19/1/44, were mated in the laboratory, and laid eggs in captivity on 2/2/44. First instar larvae hatched from these eggs on 13/2/44 and changed into second instar larvae on 29/3/44. These grubs were kept in the laboratory until December of the same year, when they died. Second instar larvae collected in the field on 21/3/44 were reared to imagines, which emerged in February of the following year, thus completing the second year of the life-cycle. No specimen conpleted the entire life-cycle in the laboratory. By means of field and laboratory observations, the length of each stage in the life-cycle was ascertained.

Oviposition extends over a period of almost two months. In 1945 in the laboratory, egg-laying commenced on 4th January, and continued until 26th March. The number of eggs present reached a maximum from 29th January to 4th February. Excavations were made at the aerodrome on 5/2/44. At a depth of six inches, forty first instar larvae and three eggs were collected. These hatched on 13/2/44. Eggs laid in the laboratory and those collected in the field were each placed in small depressions made in moist soil in the jars. This prevented the newly hatched grubs from coming into contact and injuring each other. The grubs which hatched from these eggs were placed in separate jars. During January and February, 1944, 127 eggs laid in the laboratory changed into first instar larvae. The duration of the egg stage varied from 16-47 days with an average of 26 days.

The first instar lasts for about two months. Grubs commenced to hatch in the laboratory on 4/2/45 and continued to do so until 2/4/45; the majority, however, had hatched by 23/2/45. The maximum number of first instar larvae were present between 23 February and 4th March. From the latter date the number of first instar larvae decreased, owing to the increasing number of grubs transforming into the second instar. The length of the life of a first instar larva ranged from 20-40 days, with an average of

twenty-nine days for twenty-four grubs. On 21/3/44 five first instar grubs were found about nine inches below the surface of the aerodrome. By 28/3/44 these had all transformed into second instar larvae, except for one, which remained in the first instar until 3/4/44.

The second instar is long, lasting for about fourteen and a half months. In the majority of larvae, this instar is the longest in the life-cycle. The first larval ecdysis occurs during March, the second instar being completed by May of the following year. Holes excavated on the aerodrome on 21st March, revealed that 12% of the grubs collected were in the first instar, 76% in the second instar, and 12% in the third instar. These grubs were kept in the laboratory. 30% of the second instar grubs proved to be in the second year of the life-cycle, transforming into the third instar in March-May of the same year. The remainder of the second instar grubs were in the first year of the life-cycle, presumably having turned into second instar grubs about one month previously. A small percentage of larvae changed into the third instar between September and November. The remainder lived through that year as second instar larvae, but died before changing into the third instar. Excavations on the aerodrome revealed that second instar grubs were present in the soil on 19/4/44, 3/6/44, and 13/9/44. Only one grub completed the entire second instar in the laboratory ; it spent 217 days as a second instar larva. One grub, however, spent 266 days in the second instar but died before transforming into the third instar.

The duration of the third stage is usually eight months, extending from April to December. A few larvae, as already stated, may transform into the third instar between September and November in the first year of the life-cycle. Third stage larvae were collected at the aerodrome on 21/3/44, 19/4/44, and 21/11/44. Only one grub completed the third stage in the laboratory but died before becoming a prepupa.

The duration of the prepupal stage is usually 70-80 days, and lasts from about July-January in the second year of the life-cycle. In one instance, however, the prepupal stage was only nine days long. The exact date on which the prepupal stage commences is not easy to determine, as defaècation in preparation for the prepupal stage is a gradual process. On 21/3/44 four prepupae were collected on the aerodrome. Two of these transformed into pupae in November, 1944. It is presumed that adverse conditions towards the end of 1943 prevented these larvae pupating at the end of that year. Prepupae were also collected in the field on 13/9/44 and 21/11/44. The length of the larval instars is thus about twenty months.

Pupae were present at the aerodrome for two and a half months, from the beginning of November to the middle of January. Three pupae were collected on the aerodrome on 21/9/45. The maximum number of pupae occurred during the first week in January. The duration of the pupal stage varied from 24-34 days with an average of 30 days for fifteen specimens.

Beetles were found on the wing towards the end of December ; they are usually present until the end of February or the beginning of March. The maximum period of emergence is towards the end of January. In America all species of *Anomala* are said to mature in June-August. In the laboratory in 1944, the first beetle emerged on 11th December. Sixteen beetles emerged in the laboratory, the sexes being in equal number. By 12 January seven females and one male had emerged ; by 22nd January all the males and the eighth female had emerged. It is not known if the females emerge before the males in the field. Thomas, 1925, p. 358, states that in *P. japonica* the males emerge a few days before the females. In captivity the average length of life of the imago of *A. vetula* is thirty days in both sexes.

VIII Distribution.

Adults of *A. vetula* have been collected from the coastal area of the Eastern Cape Province, between East London and Keurbooms Strand, and as far inland as Grahamstown. Peringuey, 1902, p. 592, includes Mossel Bay in its distribution. Specimens have been received from the following localities :—East London Golf Course : 3/1/45 B. Bradford, 8/1/45, 16/1/45 J. J. Naudé. Kleinemonde Natural Vegetation : Jan. 1942 J. Omer-Cooper. Port Alfred : Golf Course 11/2/39 A. B. M. Whitnall, 19/1/45 B. Bradford ; Aerodrome 23/1/44 A. B. M. Whitnall. Port Elizabeth : Walmer 4/12/40 R. W. Rand ; Cape Rd. Golf Course 13/2/42 E. M. Fenwick ; Aerodrome 19/1/44, 3/1/45 A. B. M. Whitnall, 11/1/45 B. Bradford ; Driftsands 8/1/45 S. A. Stirk. Keurbooms Strand : 29/12/41 M. Hoekstra. Grahamstown : Dec. 1940 J. Omer-Cooper, Aug. 1941 J. Glaholm, Jan. 1944, 13/2/44 J. Omer-Cooper, 17/1/45, 23/1/45 B. Bradford.

Summary.

The life-cycle of *A. vetula* is completed in two or three years, depending on the length of the prepupal stage. The larval period extends over approximately twenty months. Except for the adult stage, the entire life-cycle is passed within one foot of the surface of the ground. Imagines are present for approximately two months; they have a characteristic pungent odour. Both sexes fly ; they are not attracted to light. The larvae feed on grass roots and are a potential danger to turf ; the imagines have not been observed to feed.

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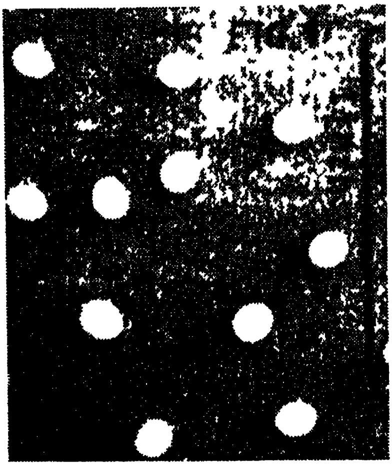
ILLUSTRATIONS.

Fig. 1.—Eggs of *A. vetula* ;

Fig. 2.—First, second and third Instar Larvae of A. vetula ;

Fig. 3.—Pupae of *A. vetula* : A. Ventral view of Male : B. Ventral view of Female : C. Dorsal view of Male : D. Dorsal view of Female ;

Fig. 4.—Male and Female Imagines of A. vetula : Diag. 1.—Diagrammatic Representation of the Experimental evidence of the length of the stages in the life-cycle of *A. vetula.*



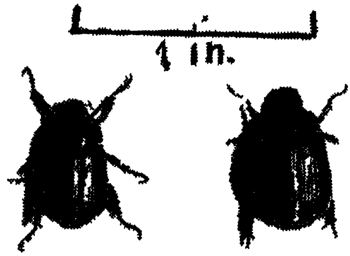


FIG. 4

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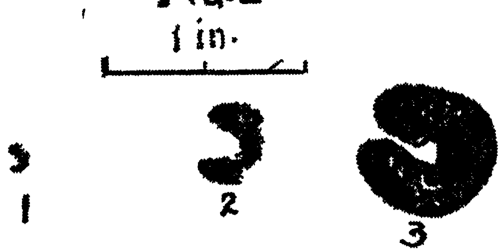
FIG. 2



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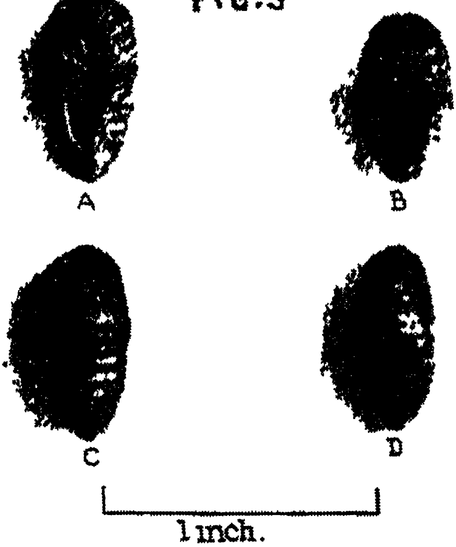

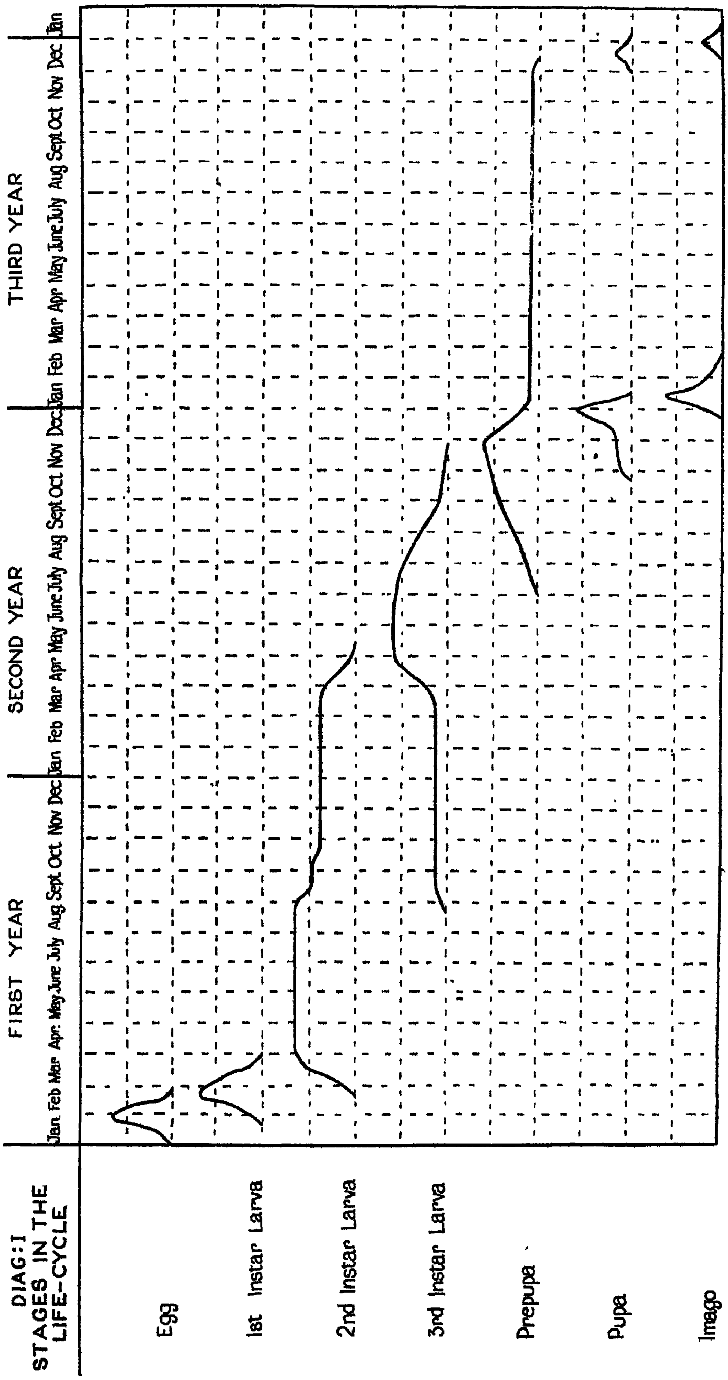
DIAG: I
STAGES IN THE LIFE-CYCLE
FIRST YEAR
SECOND YEAR
THIRD YEAR
Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec
Egg
Ist Instar Larva
2nd Instar Larva
3rd Instar Larva
Prepupa
Pupa
Imago

South African Journal of Science, *Vol. XLIV*,
pp. 148-149, March, 1948.

A COMPARISON OF SIGMOIDOSCOPY AND DIRECT STOOL EXAMINATION IN THE LABORATORY DIAGNOSIS OF AMOEBIASIS.

BY

Dr. R. Elsdon-Dew.

Department of Pathology, King Edward VIII Hospital, Durban.

Read 2nd July, 1947.

The diagnosis of amoebiasis is fraught with many difficulties, not the least of which is the finding of the parasites, which finding is the only true criterion of the diagnosis. The examination of the stool is subject to all the fallibility of any examination dependent first on sampling and second on a search for the offending parasite.

Concentration of the stool specimen by Zinc Sulphate flotation methods is effective in increasing the number of cysts found, as has been reported elsewhere(1)(2), but such a process is of little assistance with the acute case which may be passing only the fragile trophozoites, which do not survive the somewhat brutal handling. The selection of the appropriate portion of stool for examination is all important and though many technicians are adept at this technique, still much is left to chance. It is easily understood that were direct access obtainable to the source of the parasites—*viz.* the ulcers—a much higher proportion of positives might be expected. In fact, Manson-Bahr(3) attaches the greatest importance to sigmoidoscopic examination and the direct selection of specimens. On the other hand Craig(4) points out that the lesions may not be within range of the sigmoidoscope—for the caecum and ascending colon are by far the commonest sites of ulcers.

In the African, where amoebiasis is frequently present as an acute fulminating disease, rectal ulcers are common in each case(5) and it might be expected that a sigmoidoscopic selection of samples might yield a higher proportion of positive results. In a series of cases where the effects of different treatments were evaluated,(5) adjacent sigmoidoscopic and stool specimens are compared in Table I.

Table I.

Comparison of Adjacent Specimens.

Sigmoidoscopy.	*Stool.*	*No.*	%
+	+	51	46
+	−	16	14
−	+	44	40

Table II shows the case incidence of the results of examination. Here a case is designated as positive if at any time the amoeba was found by the methods indicated.

TABLE II.

Comparison of Cases.

Sigmoidoscopy.	*Stool.*	*No.*	%
+	+	54	61
+	–	2	2
–	+	33	37

It would appear therefore that there is little to be gained by the sigmoidoscopic selection of specimens even in acute amoebic dysentery.

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SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLIV, p. 150, March, 1948.*

THE ROLE OF THE FEET AS A PSYCHOLOGICAL FACTOR

BY

DR. E. S. PRIESTER,
Johannesburg.

Read 2nd July, 1947.

ABSTRACT.

Probably on account of the characteristic erect posture of Man, there is an intimate relationship between the feet and nervous and mental states. This linkage, illustrated by the fact that in many languages " well being " is equivalent to " well going ", is found to express itself in the normal psychology of the group as well as of the individual. A similar linkage is also found in pathological, physical and mental states.

Under *group psychology* may be included such aspects as: the functions of the feet in ritual and ceremonial practices; the use of the legs and feet as indices of a male or female character, which may not coincide with the actual sex; and the importance of the legs and feet in defining a beauty ideal. In *individual psychology* the feet function as instruments of self expression and tension discharge as well as inductors of erotic feeling.

Psychic disturbances, drunkenness, hypnotism and self-suggestion, fear and especially hysteria, have their special reactions on the legs and feet. Conversely, *pathological foot conditions* create nervous tensions and psychological complexes, either directly or indirectly, e.g. the " Ugliness Complex " developed in the wearer of comfortable but unfashionable shoes.

Finally, foot disorders and neuropathic manifestations may be due to a common cause, e.g. vascular disturbances or vitamin deficiencies.

South African Journal of Science, *Vol. XLIV*, *p. 151*, *March*, *1948.*

SOME NOTES ON SOCKETED BUT MOVABLE TEETH IN SNAKES AND ON THE DERMAL TEETH OF SKATES.

BY

Dr. F. Gordon Cawston,
Britannia Buildings, *Durban.*

Read 3*rd July* 1947.

Abstract.

Besides the anchylosed teeth and fangs of snakes whose pulp enables them to grow indefinitely there are numerous socketed but movable teeth and some 150 were present in *Boodon lineatus* Dumeril and Bibron, a specimen whose body length was three foot, six inches at the age of about six years, most of the teeth measuring approximately half a millimetre.

In skates the exposed dermal teeth cannot be for defence or attack, and the sensitive structure at their basal attachment indicates that they serve rather to direct currents of water onto epithelium which enables the fish to determine changes in the water medium and to detect chemical, hydrostatic and other changes in its environment.

This indicates that the recurved teeth in the mouth of a snake are associated with moulding the prey which lies in its mouth and even for extracting some taste from the skin whilst lying for long periods between its extended jaws but there is little to suggest that any of the solid teeth are shed and replaced during the life of the snake.

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EDITORIAL NOTE

The size of this volume continues the policy adopted by the Association in 1947. As outlined in the Editorial Note to Vol. XLIV, it has been decided to reduce the bulk of the Annual Journal and to issue a monthly Bulletin under the title *South African Science*. Accordingly, of the thirty papers, other than Presidential Addresses, presented at the Lourenco Marques meeting in July, 1948, only four are here printed in full, ten in abstract; and the remaining sixteen in title only. Of the latter, six have appeared in full or in abstract in Vol. II of *South African Science*.

The Editors hope that in the future it will be possible to return to the policy of publishing in full in the Journal nearly all of the papers read at the Annual Congress. Progress in this direction must however depend upon improvement in the financial resources of the Association.

While this volume has been in preparation, a change in editorial staff has taken place as a result of the appointment of Dr. A. E. H. Bleksley to succeed Professor H. H. Paine as one of the Hon. General Secretaries of the Association. The former Journal Editor has now become Editor-in-Chief, and the post of Journal Editor has been filled by a former Associate Editor of the Bulletin.

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PROCEEDINGS OF THE FORTY-SIXTH ANNUAL GENERAL MEETING OF MEMBERS, HELD IN THE MUNICIPAL BUILDING, LOURENÇO MARQUES, ON FRIDAY, 2nd JULY, 1948, AT 9.30 a.m.

Present.—Dr. S. H. Skaife (President) (in the Chair), Mr. S. B. Asher, Dr. Antonio Barradas, Eng. L. A. Barradas, Dr. A. E. H. Bleksley, Miss S. I. Bodenstein, Mrs. A. C. Cawston, Dr. F. G. Cawston, Dr. H. B. S. Cooke, Miss F. Crews, Dr. Miriam P. de Vos, Professor M. R. Drennan, Dr. R. A. Dyer, Mr. E. M. P. Evans, Mr. D. C. FitzSimons, Mrs. G. M. FitzSimons, Mrs. M. E. S. FitzSimons, Dr. V. F. FitzSimons, Dr. H. F. Frommurze, Mr. J. L. F. Garcia, Miss D. M. Gemmell, Mr. W. B. Goldschmidt, Mr. D. J. S. Gray, Mrs. E. L. Gray, Mr. James Gray, Dr. T. D. Hall, Dr. G. N. G. Hamilton, Dr. Marguerita Henrici, Dr. A. J. T. Janse, Mr. H. A. G. Jeffreys, Mrs. L. Jeffreys, Mr. J. D. Rheinallt Jones, Mr. J. E. Kerrich, Dr. D. F. Kokot, Dr. F. E. T. Krause, Dr. M. E. Malan, Mrs. A. H. Malherbe, Dr. R. H. Marloth, Mrs. R. Marloth (Senior), Dr. A. McMartin, Eng. Mario José Ferreira Mendes, Reverend W. C. Middleton, Professor John Orr, Mr. J. H. Power, Dr. J. I. Quin, Reverend Noel Roberts, Mrs. E. M. Skaife, Dr. P. S. Snyman, Dr. Alvaro Navarro Soeira, Mr. W. H. Stead, Dr. E. C. N. van Hoepen, Professor C. van Riet Lowe, Miss I. C. Verdoorn, Dr. A. R. P. Walker, Miss D. Weintroub, Professor H. H. Paine (Honorary General Secretary) and Mr. I. M. Sinclair (for Assistant General Secretaries).

1. **Minutes.**—The Minutes of the Forty-Fifth Annual General Meeting, held at Oudtshoorn on the 4th July, 1947 and printed on pages ii to xi of the Report of the Oudtshoorn Session (Volume XLIV of the Journal) were confirmed.

2. **Greetings and Apologies.**—The Honorary General Secretary reported that greetings and apologies for absence had been received from Dr. M. Boehmke, Mr. E. C. Chubb, Dr. H. H. Dodds, Mr. P. Freer, Dr. J. S. Henkel, Mr. B. D. Malan, Dr. A. G. Oettlé, Mr. F. R. Paver, Dr. E. Percy Phillips, Professor F. L. Warren and Dr. L. H. Wells.

3. **Annual Report of Council for the year ended 30th June, 1948.**—The Annual Report of the Council for the year ended 30th June, 1948, having been duly suspended on the Notice Board, was taken as read and adopted.

With reference to Item No. 13 of the Report, the President proposed a special vote of thanks to Professor and Mrs. John Orr for presenting six banners to the Association and supervising the replacement of the remaining missing banners.

A hearty vote of thanks was also accorded to the Assistant General Secretaries for the efficient manner in which they had performed their duties, special mention being made of the services rendered by Mr. A. J. Adams and Mr. I. M. Sinclair.

4. **Annual Report of the Honorary General Treasurer and Statement of Accounts for the year ended 31st May, 1948.**—The Honorary General Treasurer's Report and the Statement of Accounts for the year ended 31st May, 1948, having been duly displayed on the Notice Board, were taken as read and adopted.

5. **Annual Report of the Honorary Librarian for the year ended 31st May, 1948.**—The Annual Report of the Honorary Librarian for the year ended 31st May, 1948, having been duly displayed on the Notice Board, was taken as read and adopted.

6. **Journal and Bulletin.**—The Honorary Editor-in-Chief (Dr. A. E. H. Bleksley) reported that the monthly Bulletin (*South African Science*), which was started in August, 1947, had been very well received both in South Africa and overseas. Unfortunately, the limited finances of the Association would not permit of the publication of both the Journal and the Bulletin unless the Journal was issued in an attenuated form as had been done with the last number, but it was hoped that the reduction in the size of the Journal would prove to be only

a temporary measure pending an improvement in the finances of the Association. which were receiving the earnest consideration of the Council; the Council would, however, endeavour to arrange for the publication in appropriate Journals of all approved papers not published by this Association.

The meeting expressed its wish for continuation of the monthly Bulletin and endorsed the policy adopted by the Council of issuing an attenuated form of the Journal pending an improvement in the Association's financial position.

7&8 :—**Election of General Officers and Members of the Council for 1948/1949.**—The names of members elected as General Officers and members of the Council for the year 1948/49 are given on page ii.

Dr. G. de Kock unfortunately had to return to Pretoria the previous day because of ill health and had expressed his regret at being unable to attend this meeting. It was agreed that a telegram be sent to Dr. de Kock congratulating him on his election as President for the year 1948/49 and expressing the hope that he would make a speedy recovery to good health.

9. **Constitution and By-Laws.**—The President stated that it was necessary for the meeting to consider the revised Constitution and By-Laws of the Association, a copy of which had been suspended on the Notice Board; and, if they were approved, to adopt them with or without amendment. Details of the principal changes suggested by Council had been included on the Notice of this meeting, which had been circulated to all members.

The revised Constitution and By-Laws were adopted after Clause 16 of the Constitution had been amended to read as follows :—

Clause 16.—"The Council shall publish in the name of the Association a Journal, issued annually, which shall contain the Report of the Annual Session; and a Bulletin, issued monthly *or at such intervals as the Council may determine*, which shall contain notices of Association activities and matters of scientific interest; and may publish such other matter as it may deem advisable."

(i) Amendments put to the meeting but not adopted were :—
Clause 17 of the Constitution, Section (b) to be amended to read :—
"all Past Presidents of the Association". (Proposed by Dr. F. E. T. Krause, seconded by Professor John Orr.)

(ii) Clause 43 of the Constitution to conclude with the following sentence :—
"The Council may constitute Council members of such a Centre as a sub-committee of Council." (Proposed by Professor M. R. Drennan, seconded by Dr. H. B. S. Cooke.).

The President proposed a vote of thanks to the Sub-Committee which redrafted the Constitution and By-Laws.

10. **Resolutions from Sections C and D** :

(a) **Scientific Advisory Committee to National Parks and Nature Reserves.**—"This Association respectfully wishes to draw the attention of the Honourable the Minister of Lands (Mr. J. G. Strydom) to the memorandum sent forward by its Council, last year, to the former Minister of Lands.

Acting on the suggestions embodied in that memorandum, the former Minister of Lands called a meeting of representatives of all South African scientific and other interested bodies in November, 1947. At this meeting a committee of five was appointed to draw up a constitution for a Scientific Advisory Committee on South African National Parks and Nature Reserves, which constitution was adopted by the Minister. In terms of this constitution the various scientific and other interested bodies were invited to submit nominations for the personnel of the Advisory Committee.

This Association respectfully asks the Minister of Lands to bring this Advisory Committee into being, and respectfully suggests that all matters pertaining to the preservation of the fauna and the flora of South Africa, including the proclaiming and the deproclaiming of reserves, be referred to this advisory body before Government action is taken."

Establishment of Provincial Departments for the Conservation of Fauna and Flora.—"This Association respectfully wishes to draw the attention of the Administrators of the Provinces of Natal, the Cape of Good Hope and the Orange Free State to the farsighted policy adopted by the Administrator of the Transvaal (as a result of the findings of the Game Commission of that Province), in the appointment of both a Conservator of Fauna and Flora of the Province and of a Director of Inland Fisheries.

This Association most respectfully, but yet strongly, recommends to the Administrators of the Provinces of Natal, the Cape of Good Hope and the Orange Free State that they take similar action in regard to their Provinces, and that they create similar departments under the direction of competent, qualified biologists."

The above resolutions were adopted and referred to the Council for action.

11. **Annual Meeting, 1949.**—The President announced that the Council had accepted an invitation from the Municipality of Kimberley to hold the 1949 Annual Meeting in that city.

12. **Election of Auditors.**—Messrs. Alex Aiken and Carter were re-elected the Association's auditors for the year 1948/1949, it being agreed that their remuneration for the past audit be left in the hands of the Council.

13. **A. L. du Toit Memorial Fund.**—A letter from the Royal Society of South Africa relating to a projected A. L. du Toit Memorial Fund was referred to the Council.

14. **American Association for the Advancement of Science.**—It was agreed that the following message of greeting be sent to the American Association for the Advancement of Science, Dr. E. Percy Phillips to be asked to present the message at the anniversary celebrations of the American Association to be held in Washington from the 13th to the 17th September, 1948 :—

"We, the Members of The South African Association for the Advancement of Science meeting in Annual Session at Lourenço Marques, greet the Members of the American Association for the Advancement of Science, and congratulate them on the one-hundredth anniversary of its foundation.

The American Association plays an important part as a rallying point for students of science in America and as a means of spreading a knowledge of science amongst those interested in its progress. We note with pleasure the continued progress the American Association has made in the last hundred years and trust that its work will be rewarded with a rich harvest in the years to come."

15. **Votes of Thanks.**—On the proposal of Mr. James Gray, a unanimous vote of thanks was accorded to the following :—

To the Governor-General of Mozambique, Captain of the Navy, Gabriel Teixeira, who had extended his patronage to the Congress.

To the Mayor of Lourenço Marques, Dr. Joao Saboia Ramos, the Town Council of Lourenço Marques, the President, Eng. Mario José Ferreira Mendes, and the Council of the Sociedade de Estudos da Colonia de Moçambique for inviting the Association to hold its meeting in Lourenço Marques and for the hospitality received.

To the Local Committee for carrying out the necessary arrangements for the meeting.

To the staff of the Municipal Tourist Department and the staff of the Sociedade de Estudos da Colonia de Moçambique for clerical and other work carried out by them, particularly Mr. Xavier Valente, the Manager of the Tourist Department, and Messrs. Horacis Vianna and Bastos e Silva of the Tourist Department and the Sociedade respectively, and Mr. W. Waddington, Manager of the Publicity Department of the Railways.

To the Directorate of the General Hospital for the use of the hall and the projector for the meeting at which Dr. H. B. S. Cooke delivered the Popular Evening Lecture.

To the Town Council for arranging the concert by Jose Carlos Sequeira Costa and the Civic Ball.

To the Railway Administration for the excursion to the Villa Luiza and the flight over Maputo.

To the Port Captain, Victor Duque, for the excursion on the bay.

To the Municipal Council and the Railway Administration, under the Directorship of Major Pinto Teixeira, for transport in the town.

To the Lourenço Marques Lawn Tennis Club and the Lourenço Marques Golf Club for extending the privileges of Honorary Membership to members of the Association attending the meeting.

To the Press for their reports of the meeting.

Mr. James Gray concluded by conveying the appreciation of members of this Association to the citizens of Lourenço Marques for the courtesy extended by them and expressed the hope that it would be possible to have another meeting in Lourenço Marques in the comparatively near future.

Professor A. Quintanilha expressed the appreciation of the Government of Mozambique and of the Sociedade de Estudos da Colonia de Mozambique at the acceptance by this Association of the invitation to hold the 1948 Annual Meeting in Lourenço Marques.

Dr. F. E. T. Krause proposed a hearty vote of thanks to the President (Dr S. H. Skaife) for the services he had rendered the Association during his term of office and for the able manner in which he had presided over the annual session :— this vote of thanks was accorded with acclamation.

This concluded the business and the meeting terminated at 11.45 a.m.

VERRIGTINGS VAN DIE SES-EN-VEERTIGSTE ALGEMENE JAARVERGADERING VAN LEDE, GEHOU IN DIE MUNISIPALE GEBOU, LOURENÇO MARQUES, OP VRYDAG, 2 JULIE 1948, OM 9.30 v.m.

Teenwoordig.—Dr. S. H. Skaife (President) (in die Voorsitterstoel), Mnr. S. B. Asher, Dr. Antonio Barradas, Ing. L. A. Barradas, Dr. A. E. H. Bleksley, Mej. S. I. Bodenstein, Mev. A. C. Cawston, Dr. F. G. Cawston, Dr. H. B. S. Cooke, Mej. F. Crews, Dr. Miriam P. de Vos, Prof. M. R. Drennan, Dr. R. A. Dyer, Mnr. E. M. P. Evans, Mnr. D. C. FitzSimons, Mev. G. M. FitzSimons, Mev. M. E. S. FitzSimons, Dr. V. F. FitzSimons, Dr. H. F. Frommurze, Mnr. J. L. F. Garcia, Mej. D. M. Gemmell, Mnr. W. B. Goldschmidt, Mnr. D. J. S. Gray, Mev. E. L. Gray, Mnr. James Gray, Dr. T. D. Hall, Dr. G. N. G. Hamilton, Dr. M. Henrici, Dr. A. J. T. Janse, Mnr. H. A. G. Jeffreys, Mnr. J. D. Rheinallt Jones, Mnr. J. E. Kerrich, Dr. D. F. Kokot, Dr. F. E. T. Krause, Dr. M. E. Malan, Mev. A. H. Malherbe, Dr. R. H. Marloth, Mev. R. Marloth (Senior), Dr. A. McMartin, Ing. Mario José Ferreira Mendes, Eerw. W. C. Middleton, Prof. John Orr, Mnr. J. H. Power, Dr. J. I. Quin, Eerw. N. Roberts, Mev. E. M. Skaife, Dr. P. S. Snyman, Dr. Alvaro N. Soeira, Mnr. W. H. Stead, Dr. E. C. N. van Hoepen, Prof. C. v. Riet Lowe, Mej. J. C. Verdoorn, Dr. A. R. P. Walker, Mej. D. Weintroub, Prof. H. H. Paine (Ere-Algemene-Sekretaris), en Mnr. I. M. Sinclair (vir Assistent-Algemene Sekretarisse).

1. **Notule.**—Die Notule van die Vyf-en-veertigste Algemene Jaarvergadering gehou te Oudtshoorn op 4 Julie 1947 en gedruk op bladsye ii tot xi van die verslag van die Oudtshoornse Byeenkoms (Deel XLIV van die Joernaal) is goedgekeur.

2. **Groete en Verontskuldigings.**—Die Ere-Algemene Sekretaris het gerapporteer dat groete saam met verontskuldigings vir afwesigheid ontvang is van Dr. M. Boehmke, Mnr. E. C. Chubb, Dr. H. H. Dodds, Mnr. P. Freer, Dr. J. S. Henkel, Mnr. B. D. Malan, Dr. A. G. Oettlé, Mnr. F. R. Paver, Dr. E. Percy Phillips, Prof. F. L. Warren en Dr. L. H. Wells.

3. **Jaarverslag van die Raad vir die Jaar eindigende 30 Junie 1948.**—Die Jaarverslag van die Raad vir die jaar eindigende 30 Junie, 1948, wat behoorlik op die kennisgewingsbord gepubliseer was, is as gelees beskou en aangeneem.

Met verwysing na Item 13 van die verslag het die President 'n spesiale mosie van dank aan Professor en Mevrou John Orr voorgestel, vir die geskenk van ses baniere aan die Genootskap, en vir die oorsig oor die hernuwing van die orige baniere wat verlore gegaan het.

'n Hartlike mosie van dank is ook aan die Assistent-Algemene Sekretarisse vir die doeltreffende manier waarop hulle hul pligte uitgevoer het aangeneem: daar is in die besonder na die dienste deur Mnr. A. J. Adams en Mnr. I. M. Sinclair gelewer verwys.

4. **Die Jaarverslag van die Ere-Algemene Penningmeester en Staat van Rekeninge vir die jaar tot op 31 Mei 1948,** wat behoorlik op die Kennisgewingsbord gepubliseer is, is as gelees beskou en goedgekeur.

5. **Die Jaarverslag van die Ere-Bibliotekaris vir die jaar tot op 31 Mei 1948,** wat behoorlik op die Kennisgewingsbord gepubliseer is, is as gelees beskou en goedgekeur.

6. **Joernaal en Bulletin.**—Die Ere-Hoof-Redakteur (Dr. A. E. H. Bleksley) het berig dat die maandelikse Bulletin (Suid-Afrikaanse Wetenskap) wat in Augustus 1947 gestig is, baie gunstige ontvangs beide in Suid-Afrika en in die buiteland gehad het. Ongelukkig maak die beperkte finansies van die Genootskap dit onmoontlik om beide die Joernaal en die Bulletin uit te gee tensy die Joernaal ingekort word soos met die laaste Deel van die Joernaal gedoen is. Daar word egter gehoop dat die inkorting van die Joernaal slegs 'n tydelike maatreël sal wees, wat met 'n verbetering in die finansiële posisie van die Genoot-

skap weer onnodig sal word. Die saak ontvang die ernstige aandag van die Raad ; die Raad sal egter pogings aanwend om alle verdienstelike bydraes wat nie deur die Genootskap gepubliseer word nie, in paslike ander tydskrifte gepubliseer te kry.

Die vergadering het die mening uitgespreek dat daar met die uitgawe van die maandelikse bulletin voortgegaan moet word, en het die beleid van die Raad insake die uitgee van 'n verkorte Joernaal totdat daar 'n verbetering in die finansiële posisie van die Genootskap kom ondersteun.

7 & 8 :—**Verkiesing van Algemene Ampsdraers en Raadslede vir 1948/1949.**— Die name van die lede wat tot algemene Ampsdraers en Raadslede vir die jaar 1948/49 gekies is word op bladsy ii aangegee.

Ongelukkig moes Dr. G. de Kock die vorige dag weens ongesteldheid na Pretoria terugkeer, en het hy sy leedwese uitgespreek dat hy nie by die vergadering teenwoordig kon wees nie. Dit is besluit om 'n telegram aan Dr. de Kock te stuur om hom met sy verkiesing tot President vir die jaar 1948/1949 geluk te wens, en om die hoop uit te spreek dat hy spoedig sal herstel.

9. **Konstitusie en Bywette.**—Die President het verklaar dat dit vir die vergadering nodig was om die hersiende Konstitusie en Bywette van die Genootskap te oorweeg, 'n afdruk waarvan op die Kennisgewingbord vertoon is ; as dit goedgekeur word moet die vergadering dit, met of sonder amendement, aanneem. Besonderhede van die voorgestelde veranderings wat deur die Raad voorgestel word is in die Kennisgewing van die vergadering ingesluit, en is aan alle lede uitgestuur.

Die hersiende Konstitusie en Bywette is aangeneem nadat Klousule 16 van die Konstitusie amendeer is om as volg te lees :—

Klousule 16.—„Die Raad sal in die naam van die Genootskap 'n Joernaal, jaarliks uitgegee, en wat 'n verslag oor die Jaarvergadering sal bevat, en 'n Bulletin, wat maandeliks of by sulke tussenposes soos deur die Raad besluit uitgegee sal word, waarin daar kennisgewings van Genootskapsake en sake van wetenskaplike belang opgeneem sal word publiseer ; en mag sulke ander materiaal publiseer as wat hy goed dink".

Amendemente wat voorgestel is maar nie aangeneem nie, was :

(i) Klousule 17 van die Konstitusie, Seksie (b) amendeer te word om te lees :—

„alle Oud-Presidente van die Genootskap".

(Voorgestel deur Dr. F. E. T. Krause, gesekondeer deur professor John Orr.)

(ii) Klousule 43 van die Konstitusie met die volgende sin te eindig :—

„Die Raad mag Raadslede van sodanige Sentrum as 'n Sub-komitee van die Raad aanstel".

(Voorgestel deur Professor M. R. Drennan, gesekondeer deur dr. H. B. S. Cooke.)

Die President het 'n mosie van dank voorgestel aan die Sub-komitee wat die Konstitusie en Bywette heropgetrek het.

10. **Besluite van Afdelings C en D :**

(a) **Wetenskaplike Adviserende Komitee vir Nasionale Parke en Natuurreserwes.**—„Die Genootskap wens beleef om die aandag van Sy Ed. die Minister van Lande (Mnr. J. G. Strydom) op die memorandum te vestig wat verlede jaar deur die Raad aan die vorige Minister van Lande gestuur is.

Handelende op die voorstelle wat in die memorandum bevat is, het die vorige Minister van Lande 'n vergadering van verteenwoordigers van alle Suid-Afrikaanse wetenskaplike en ander belangstellende liggame in November 1947 belê. By die vergadering is 'n komitee van vyf lede aangestel om 'n konstitusie vir 'n Wetenskaplike Adviserende Raad vir Suid-Afrikaanse Nasionale Parke en Natuurreserwes op te trek. In terme van die konstitusie is die verskeie

wetenskaplike en ander belangstellende liggaame uitgenooi om nominasies in te stuur vir die lede van die Adviserende Komitee.

Die Genootskap wil die Minister van Lande beleef versoek om die Adviserende Raad in die lewe te roep, en wil beleef voorstel dat alle sake in verband met die behoud van die fauna en flora van Suid-Afrika, insluitende die proklamasie en deproklamasie van reserwes na die adviserende liggaam verwys word alvorens daar deur die Regering stappe geneem word.''

(b) **Stigting van Provinsiale Departemente vir die Behoud van Fauna en Flora.**—,,Die Genootskap wil beleef die aandag van die Administrateurs van die Provinsies van Natal, Kaap die Goeie Hoop, en die Oranje Vrystaat vestig op die versigtige beleid wat deur die Administrateur van die Transvaal aangeneem is (as gevolg van die bevindinge van die Wildkommissie van die Provinsie), naamlik in die aanstelling van beide 'n Konservator van Fauna en Flora van die Provinsie, en van 'n Direkteur van Binnelandse Visserye.

Die Genootskap beveel beleef dog dringend op die Administrateurs van die Provinsies van Natal, Kaap die Goeie Hoop, en die Oranje Vrystaat aan dat hulle soortgelyke stappe met betrekking tot hul Provinsies neem, en dat hulle soortgelyke departemente onder leiding van bevoegde opgeleide bioloë stig''.

Bogenoemde besluite is aangeneem en na die Raad vir handeling verwys.

11. **Jaarvergadering—1949.**—Die President het aangekondig dat die Raad in uitnodiging van die Stadsraad van Kimberley om die Jaarvergadering 1949 'n dié stad te hou aangeneem het.

12. **Verkiesing van Ouditeure.**—Die Here Alex Aiken en Carter is herkies as Ouditeure vir die Genootskap vir die jaar 1948/1949, en dit is besluit om die vergoeding vir die afgelope ouditering in die hande van die Raad te laat.

13. **A. L. du Toit-Gedenkfonds.**—'n Brief van die Koninklike Vereniging van Suid-Afrika insake 'n voorgestelde A. L. du Toit-Gedenkfonds is na die Raad verwys.

14. **Amerikaanse Genootskap vir die Bevordering van Wetenskap.**—Dit is besluit dat die volgende boodskap van heilwense aan die Amerikaanse Genootskap vir die Bevordering van Wetenskap gestuur word, en dat Dr. E. Percy Phillips gevra word om die boodskap by die eeufeesviering van die Amerikaanse Genootskap wat te Washington vanaf 13 tot 17 September plaasvind oor te dra :—

,,Ons, die lede van die Suid-Afrikaanse Genootskap vir die Bevordering van Wetenskap in Jaarvergadering te Lourenço Marques byeengekom, groet die lede van die Amerikaanse Genootskap vir die Bevordering van Wetenskap, en felisiteer hulle met die honderdste verjaardag van sy stigting.

Die Amerikaanse Genootskap speel 'n belangrike rol as 'n brandpunt vir studente van die wetenskap in Amerika en as 'n middel tot die verspreiding van 'n kennis van die wetenskap onder diegene wat in sy vooruitgang belangstel. Ons neem met genoeë kennis van die onafgebroke vooruitgang van die Amerikaanse Genootskap gedurende die afgelope honderd jaar, en vertrou dat sy arbeid met ryke vrugte in die jare te kom beloon sal word.''

15. **Mosies van Dank.**—Op voorstel van Mnr. James Gray is 'n eenparige mosie van dank aan die volgende persone aangeneem :—

Aan Sy Eksellensie die Goewerneur-generaal van Moçambique, Kaptein van die Oorlogsvloot, Gabriel Teixeira, vir sy beskerming en ondersteuning van die Byeenkoms.

Aan Sy Edelagbare die Burgemeester van Lourenço Marques, Dr. Joao Saboia Ramos en die Stadsraad van Lourenço Marques, die President (Ing. Mario Jose Ferreira Mendes) en die Raad van die Sociedade de Estudos da Colonia de Moçambique vir hul uitnodiging aan die Genootskap om die Jaarvergadering in Lourenço Marques te hou asook vir die gasvryheid wat ontvang is.

Aan die Plaaslike Komitee vir die uitstekende reëlings wat vir die vergadering getref is.

Aan die personeel van die munisipale toeriste departement en die personeel van die Sociedade de Estudos da Colonia de Moçambique vir klerikale en ander werk uitgevoer, in die besonder aan Mnr. Xavier Valente, bestuurder van die toeriste departement, aan die here Horacis Vianna en Bastos e Silva, respektiewelik van die toeriste departement en van die Sociedade, en aan Mnr. W. Waddington, bestuurder van die spoorwegpublisiteitsdepartement.

Aan die direkteure van die Algemene-Hospitaal vir die gebruik van die saal en projeksielamp deur die vergadering terwyl Dr. H. B. S. Cooke sy populêre aand-lesing gehou.

Aan die Stadsraad vir verskaffing van die Konsert deur Jose Carlos Sequeira Costa en van die burgelike bal.

Aan die spoorwegadministrasie vir die uitstappie na Villa Luiza en die vlug bokant Maputo.

Aan die hawekaptein Mnr. Victor Duque vir die ekskursie op die baai.

Aan die stadsraad en die spoorwegadministrasie onder die besturing van Majoor Pinto Teixeira, wat vervoer in die stad verskaf het.

Aan die Lourenço Marques Lawn Tennis Club en die Lourenço Marques Golf Club vir voorregte van Erelidmaatskap gedurende die Sitting.

Aan die Pers vir verslaggewing van verhandelinge op die Vergadering gelees.

Ten slotte het Mnr. James Gray die waardering van die lede van die Genootskap aan die burgers van Lourenço Marques oorgedra vir die hoflikheid wat hulle ontvang het, en het die hoop uitgespreek dat dit moontlik sal wees om in die betreklike nabye toekoms weereens in Lourenço Marques te mag byeenkom.

Professor A. Quintanilha het die waardering van die Regering van Mozambique en van die Sociedade de Estudos da Colonia de Moçambique vir die aanname deur die Genootskap van die uitnodiging om die Jaarvergadering in 1948 te Lourenço Marques te hou uitgespreek.

Dr. F. E. T. Krause het 'n hartlike mosie van dank aan die President (Dr. S. H. Skaife) voorgestel, vir die dienste wat hy gedurende sy ampstermyn aan die Genootskap gelewer het, asook vir die bekwame wyse waarop hy as voorsitter by die jaarlikse byeenkoms opgetree het. Die mosie is met applous aangeneem.

Daarmee is die verrigtings afgesluit, en die vergadering het om 11.45 v.m. geëindig.

REPORT OF COUNCIL FOR THE YEAR ENDED 30TH JUNE, 1948.

1. **Obituary.**—Your Council reports with regret the death of the following members :—

Mr. E. W. Balderson, Miss D. F. Bleek, Mr. J. B. D. Clark, Dr. E. G. Dru Drury, Dr. A. L. du Toit, Mr. P. Ross Frames, Mr. L. Hall, Mr. F. Hirschhorn, Reverend P. Loze, Mr. H. Middlebrook, Dr. Austin Roberts, Mr. A. Slossberg, Mr. W. Spilhaus, Sir William Thomson and Mr. J. T. E. Wingfield.

2. **Membership.**—Since the last report, eighty-six members have joined the Association, fifteen have died, nine have resigned and the names of eleven members have been removed from the Membership List in accordance with the provisions of Clause 7 of the Constitution.

The following table shows a comparative list of the geographical distribution of membership as at 30th June, 1947 and 30th June, 1948 :—

	1947	1948
Transvaal	508	540
Cape of Good Hope	187	188
Natal	79	77
Orange Free State	23	21
Southern and Northern Rhodesia	13	16
South West Africa	1	3
Moçambique	3	11
Abroad	31	40
	845	896

3. **The Journal.**—Volume XLIV of the *South African Journal of Science* containing the Annual Reports of the Association for the year ended 30th June, 1947, was forwarded to members in June, 1948. It consisted of 25 pages of Reports, Accounts and official matter, 157 pages of scientific contributions including seven presidential addresses and 18 contributions of which eight were printed in abstract and five in title only, together with indexes, illustrations, etc.

4. **Bulletin.**—During the year the Association has taken an important step in founding its monthly Bulletin, *South African Science*, the first issue of which appeared in August, 1947. The new publication has met with a very good reception both in South Africa and overseas, and quite clearly meets a need that has existed in South Africa for a scientific monthly which embodies reports on research in this country as well as reviews of work in other countries. If the Association is to continue with this venture, however, it is imperative that more support be obtained from advertisers, as the cost of publication is at present very high.

5. **Future Policy and Activities.**—The Committee on Future Policy and Activities arranged lectures to the public at Johannesburg as well as continuing the series of Schools Lectures commenced early in 1947. Various circumstances have made it impossible to organise similar lectures during the first half of 1948, but it is hoped to organise a series of Schools Lectures on rather different lines during the latter half of this year.

A gratifying feature of the year's activities has been the organisation of Public Lectures in various other centres ; such lectures have done much to stimulate public interest in matters of scientific importance.

6. **South Africa Medal and Grant—1948.**—The South Africa Medal and Grant for the year 1948 has been awarded to Dr. A. J. T. Janse.

7. **British Association Medal and Grant—1948.**—No award.

8. **Certificates of Merit—1947.**—Certificates of Merit have been awarded to Ethel Lilian Gray (History), John Hyacinth Power (Geology and Palaeontology) and James Archibald Swan (Prehistoric Archaeology).

9. **Donations.**—The thanks of the Association are due to the Honourable the Minister of Education for a grant of £250 towards the expenses of the publication of the Journal and the Bulletin, and to the Johannesburg Municipality for a grant of £100.

10. **Resolutions of Annual General Meeting—1947**:

(a) **Protection and Control of Fauna, Flora and Sanctuaries of South Africa**: The resolution on the desirability of forming an Outeniqua National Park brought a favourable reply from the Minister of Lands.

(b) **Summaries of Papers for Annual Session.**—The Council has arranged for the distribution to Members of Sections concerned of short summaries of papers to be read at the Annual Session if these are handed in to the office in time for their duplication.

11. **National Parks and Nature Reserves.**—The Minister of Lands has decided to appoint a "Scientific Advisory Council for National Parks and Nature Reserves". The Association was invited to submit nominations for this Advisory Council, and the Council of the Association sent in a list of seven names.

12. **Revision of Constitution.**—The Council has redrafted the Constitution and By-Laws of the Association. The revised Constitution will be placed before the Annual General Meeting for acceptance.

13. **Banners of the Association.**—The Presidential Banners of the Association have now been completed. Those of the six Meetings in Johannesburg during the war have been presented by Professor and Mrs. John Orr. Professor Orr has also supervised the replacement of those banners of previous years that had been lost.

A kist to contain the banners has been made and presented to the Association by the firm of Messrs. Duncan Bayne (Pty.), Ltd. and Council is grateful for this gift.

14. **Annual Session—1949.**—The Council has accepted on behalf of the Association an invitation from the Municipality of Kimberley to hold the 1949 Annual Session in Kimberley.

15. **The New Council.**—On the basis of membership provided in the Constitution, Section 22, the number of members of Council assigned to each Centre during the ensuing year should be as follows:—

Transvaal:	
Witwatersrand	23
Pretoria	10
Outside Districts	2
Province of the Cape of Good Hope:	
Cape Peninsula and District	5
Stellenbosch and District	2
East London and Port Elizabeth	1
Grahamstown and King William's Town and District	2
Kimberley	1
Oudtshoorn	2
Outside Districts	1
Natal:	
Durban and District	3
Pietermaritzburg and Outside Districts	2
Orange Free State:	
Bloemfontein and District	2
Southern Rhodesia	1
	57

16. **Secretariat.**—The Council expresses its appreciation of the services of The Associated Scientific and Technical Societies of South Africa in carrying out the secretarial work of the Association during the year and once more draws attention to the continuous and valuable help given by Mr. A. J. Adams and Mr. I. M. Sinclair.

VERSLAG VAN DIE RAAD VIR DIE JAAR EINDIGENDE 30 JUNIE 1948.

1. **In Memoriam.**—U Raad gee met leedwese kennis van die oorlyding van die volgende lede :—

Mnr. E. W. Balderson, Mej. D. F. Bleek, Mnr. J. B. D. Clark, Dr. E. G. Dru Drury, Dr. A. L. du Toit, Mnr. P. Ross Frames, Mnr. L. Hall, Mnr. F. Hirschhorn, Eerw. F. Loze, Mnr. H. Middlebrook, Dr. Austin Roberts, Mnr. A. Slossberg, Mnr. W. Spilhaus, Sir William Thomson, en Mnr. J. T. E. Wingfield.

2. **Ledetal.**—Sedert die jongste verslag het ses-en-tagtig lede by die Genootskap aangesluit, vyftien is oorlede, nege het bedank, en die name van elf is van die Ledelys geskrap volgens die bepalings van Klousule 7 van die Konstitusie.

Die volgende lys toon vergelykenderwys die geografiese verspreiding van lede op 30 Junie 1947 en 30 Junie 1948 :—

	1947	1948
Transvaal	508	540
Kaapland	187	188
Natal	79	77
Oranje-Vrystaat	23	21
Suid- en Noord-Rhodesië	13	16
Suid-wes Afrika	1	3
Moçambique	3	11
Oorsee	31	40
	845	896

3. **Die Joernaal.**—Deel XLIV van *Die Suid-Afrikaanse Joernaal van Wetenskap* wat die Jaarverslag van die Genootskap vir die jaar tot op 30 Junie 1947 bevat, is in Junie 1948 aan lede uitgegee. Dit beslaan 25 bls. van Verslae, Rekenings, en offisiële stof, 157 bls. van wetenskaplike bydraes, insluitende sewe presidentsredes en agtien bydraes waarvan 8 by wyse van opsomming en 5 by wyse van titel gepubliseer is, tesame met inhoudsopgawes, illustrasies, ens.

4. **Die Bulletin.**—Gedurende die jaar het die Genootskap 'n belangrike voorwaartse stap geneem met die stigting van 'n maandelikse Bulletin, *Suid-Afrikaanse Wetenskap*, waarvan die eerste uitgawe in Augustus 1947 verskyn het. Die nuwe publikasie het 'n baie goeie ontvangs beide in Suid-Afrika en in die buiteland gehad, en voorsien klaarblyklik aan 'n behoefte wat in Suid-Afrika bestaan het vir 'n wetenskaplike maandblad waarin opgeneem word verslae oor navorsing wat in die land uitgevoer is, sowel as oorsigte oor werk in ander lande. As die Genootskap met die onderneming moet voortgaan, is dit egter noodsaaklik dat daar meer ondersteuning van adverteerders verkry moet word, aangesien die koste aan die uitgee van so'n blad verbonde op die huidige oomblik baie hoog is.

5. **Toekomstige Beleid en Aktiwiteite.**—Die Komitee vir Toekomstige Beleid en Aktiwiteite het openbare voorlesings in Johannesburg gereël, sowel as om die reeks voorlesings vir Skole waarmee vroeg in 1947 'n aanvang geneem is verder te voer. Verskeie omstandighede het dit onmoontlik gemaak om soortgelyke lesings gedurende die eerste helfte van 1948 te reël, maar die hoop word gekoester dat 'n reeks Skool Voorlesings in 'n effens gewysigde vorm gedurende die tweede helfte van die jaar gereël sal kan word.

'n Verblydende kenmerk van die bedrywighede van die jaar was die organisasie van Publieke voorlesings in verskeie ander sentrums ; sulke voorlesings het veel gedoen om publieke belangstelling in sake van wetenskaplike belang aan te wakker.

6. **Suid-Afrika Medalje en Toekenning—1948.**—Die Suid-Afrika Medalje en Toekenning vir die jaar 1948 is aan Dr. A. J. T. Janse toegeken.

7. **Brits Genootskap Medalje en Toekenning.**—Geen toekenning.

8. **Meriete-Sertifikate—1947.**—Meriete-sertifikate is aan Ethel Lilian Gray (Geskiedenis), John Hyacinth Power (Geologie en Paleontologie), en James Archibald Swan (Prehistoriese Argeologie) toegeken.

9. **Donasies.**—Die Genootskap spreek sy dank uit aan Sy Ed. die Minister van Finansies en van Onderwys vir 'n donasie van £250 tot die onkoste van die Joernaal, en aan die Johannesburgse Munisipaliteit vir 'n toelae van £100.

10. **Besluite aangeneem by die Algemene Jaarvergadering—1947.**

(a) **Beskerming en beheer van die fauna, flora, en sanctuaria in Suid-Afrika:**—Die besluit aangaande die wenslikheid van die stigting van 'n Outeniqua Nasionale Park het 'n gunstige antwoord van die Minister van Lande ontvang.

(b) **Opsommings van bydraes tot die Jaarlikse Byeenkoms.**—Die Raad het reëlings getref vir die omstuur aan Lede van die betrokke Afdelings van opsommings van verhandelings wat by die Jaarlikse Byeenkoms gelees gaan word, indien sulke opsommings die kantoor betyds bereik.

11. **Nasionale Parke en Natuurreserwes.**—Die Minister van Lande het besluit om 'n „Wetenskaplike Adviserende Raad vir Nasionale Parke en Natuurreserwes" aan te stel. Die Genootskap is uitgenooi om nominasies tot die Adviserende Raad te maak, en die Raad van die Genootskap het 'n lys van sewe name ingestuur.

12. **Hersiening van die Konstitusie.**—Die Raad het die Konstitusie en Bywette van die Genootskap opnuut opgetrek. Die hersiende Konstitusie sal voor die Algemene Jaarvergadering vir goedkeuring gelê word.

13. **Baniere van die Genootskap.**—Die Presidentsbaniere van die Genootskap is nou voltallig. Die ses wat betrekking het op die Jaarvergaderings te Johannesburg gedurende die oorlog is aan die Genootskap deur Professor en Mevrou John Orr geskenk. Professor Orr het ook toesig gehou oor die vernuwing van die baniere van vorige jare wat verlore gegaan het.

'n Kis om die baniere te bevat is deur die firma Duncan Bayne (Edms.) Bpk. gemaak en aan die Genootskap geskenk, en die Raad spreek hiervoor sy dank uit.

14. **Jaarvergadering—1949.**—Die Raad het namens die Genootskap 'n uitnodiging deur die Stadsraad van Kimberley om die Jaarvergadering in 1949 te Kimberley te hou aangeneem.

15. **Die Nuwe Raad.**—Op basis van die ledetal, soos in Klousule 22 van die Konstitusie bepaal, is die aantal Raadslede aan elke Sentrum vir die volgende jaar toegeken as volg:

Transvaal:	
Witwatersrand	23
Pretoria	10
Buite Distrikte	2
Provinsie van die Kaap die Goeie Hoop:	
Kaapse Skiereiland en Distrik	5
Stellenbosch en Distrik	2
Oos-Londen en Port Elizabeth	1
Grahamstad en King William's Town en Distrik	2
Kimberley	1
Oudtshoorn	2
Buite Distrikte	1
Natal:	
Durban en Distrik	5
Pietermaritzburg en Buitedistrikte	2
Oranje-Vrystaat:	
Bloemfontein en Distrik	2
Suid-Rhodesië	1
	57

16. **Sekretariaat.**—Die Raad bring sy dank aan die Verenigde Wetenskaplike en Werktuigkundige Verenigings vir hulle dienste as Assistent-Algemene Sekretarisse van die Genootskap gedurende die jaar, en vestig weereens aandag op die onafgebroke en waardevolle hulp wat Mnr. A. J. Adams en Mnr. I. M. Sinclair verleen het.

Report of Honorary General Treasurer for the Year ended 31st May, 1948.

As members are aware, it was agreed last year to alter the policy of the Association with regard to publications. Consequently, a much improved and enlarged monthly scientific Bulletin of a topical nature has been issued to members. By this means, a closer liaison has been established between the members and the Association which is to the advantage of both. An attenuated *Journal of Science* containing the Presidential Address and the addresses of Presidents of Sections and other selected contributons has been issued also.

As was to be expected these changes increased printing charges but revenue from advertisements, donations, sales and reprints reduced these considerably and the net cost of the two publications was approximately £300 less than last year.

All other items of expenditure are normal and revenue has increased by £42 from subscriptions. The increase in membership shown last year has not been maintained.

The final result shows an excess of expenditure over income of £81 11s. 6d., as compared with £239 13s. 6d. last year. While this further loss reduces the Income and Expenditure Account to £255 13s. 9d., I consider that the result of the year's working has been reasonably satisfactory, especially in view of the changed policy. Nevertheless, the position demands consideration and additional revenue must be found if the Association is to continue to function as the premier scientific association in South Africa.

The Council has realised the position and is taking immediate steps to examine the question.

Renewed thanks must be expressed to the Union Department of Education and to the City Council of Johannesburg, who, by their donations continue to recognise the value of the services rendered by the Association to science in South Africa.

JAS. GRAY,
Honorary General Treasurer.

Verslag van die Ere-Algemene Penningmeester vir die jaar eindigende 31 Mei 1948.

Soos wellig aan Lede bekend, is verlede jaar besluit om die beleid van die Genootskap insake sy publikasies te wysig. Gevolglik is daar 'n veel-verbeterde en vergrote maandelikse wetenskaplike Bulletin van 'n aktuele aard aan lede uitgegee. Hierdeur is daar 'n nouer verband tussen die lede en die Genootskap getref, wat tot die voordeel van beide gewerk het. 'n Verkleinde Joernaal van Wetenskap wat die Presidentsrede en dié van die Afdelingspresidente, sowel as ander uitgesogte bydraes bevat, is ook uitgegee.

Soos verwag kon word, het die veranderings tot verhoogde drukkoste gelei, maar inkomste uit advertensies, donasies, verkopings en afdrukke het die onkoste aansienlik verminder, sodat die totale koste van die twee publikasies sowat £300 minder is as verlede jaar.

Alle ander items van uitgawe is normaal, en inkomste het met £42 uit jaargelde toegeneem. Die toename in lidmaatskap wat verlede jaar vertoon is, is nie vanjaar gehandhaaf nie.

Die finale uitslag toon aan 'n oormaat van uitgawe oor inkomste van £81 11s. 6d., in vergelyking met £239 13s. 6d verlede jaar. Terwyl die verdere verlies die Inkoms en Uitgawe Rekening tot op £255 13s. 9d. verminder, beskou ek die resultaat van die jaar se aktiwiteite as redelik bevredigend, vernaamlik in die lig van die nuwe beleid. Nogtans verdien die toestand aandag, en addisionele inkomste moet gevind word as die Genootskap as die hoof wetenskaplike Genootskap in Suid-Afrika met sy werksaamhede wil volhou.

Die Raad het die posisie besef en neem dadelik stappe om die probleem in oënskou te neem.

Hernude dank moet uitgespreek word aan die Unie Departement van Onderwys en die Stadsraad van Johannesburg, wie by wyse van hul donasies steeds die waarde van die dienste herken wat die Genootskap aan die saak van die wetenskap in Suid-Afrika lewer.

JAS. GRAY,
Ere-Algemene Penningmeester.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
BALANCE SHEET AT 31st MAY, 1948.

LIABILITIES.

	£ s. d.	£ s. d.
Sundry Creditors:		
General Accounts	156 5 0	
Grants to Local Centres under Rule 35	62 3 6	
Subscriptions paid in Advance	49 2 6	
Endowment Fund	27 1 1	
Recipient South Africa Medal Award, 1948	40 11 6	
		335 3 7
Library Binding and Equipment Account.		
Balance at 31st May, 1947	314 2 11	
Add Interest from Library Endowment Fund	73 17 11	
	388 0 10	
Less Expenditure during the year	199 7 4	
		188 13 6
Income and Expenditure Account:		
Balance at 31st May, 1947	337 5 3	
Less Excess of Expenditure over Income for the year ended 31st May, 1948	81 11 6	255 13 9
		779 10 10
Endowment Fund		3,438 14 5
Library Endowment Fund		2,164 11 6
South Africa Medal Fund		1,755 18 5
British Association Medal Fund		564 3 8
		£8,702 18 10

ASSETS.

	£ s. d.	£ s. d.
Cash:		
At Bank	174 5 1	
At Post Office Savings Bank with interest accrued	43 18 11	
At United Building Society, St. Andrew's Branch with interest accrued	427 7 11	
		645 11 11
Sundry Debtors:		
Library Endowment Fund	3 17 11	
Advertisers in Journal and Bulletin	94 3 0	
		98 0 11
Furniture:		
Balance at 31st May, 1947	13 10 0	
Add Purchase during year	28 10 0	
	42 0 0	
Less Depreciation	8 10 0	
		33 10 0
Medal on Hand		18 0
Deposit—Post Office		1 10 0
		779 10 10
Trustees—Endowment Fund—As per separate account		3,438 14 5
Library Endowment Fund—As per separate account		2,164 11 6
Trustees—South Africa Medal Fund—As per separate account		1,755 18 5
Trustees—British Association Medal Fund—As per separate account		564 3 8
		£8,702 18 10

We have examined the books accounts and vouchers of The South African Association for the Advancement of Science for the year ended 31st May, 1948, and have obtained all the information and explanations we have required. We have satisfied ourselves of the existence of the securities. Proper books and accounts have been kept. In our opinion the above Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of affairs of the Association at 31st May, 1948, according to the best of our information and the explanations given to us and as shown by the books of the Association as at 31st May, 1948.

Johannesburg.
16th June, 1948.

ALEX. AIKEN & CARTER,
Auditors.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY 1948.

Dr.

	£ s. d.	£ s. d.	£ s. d.
To Secretarial Fees		.. ..	300 0 0
„ Journal and Bulletin Expenses		1.423 1 0	
Less Government Grant ..	250 0 0		
Johannesburg Municipal Grant	100 0 0		
Sales, Reprints and Advertisements	591 10 4		
		941 10 4	
			481 10 8
„ Stationery and Printing			84 12 7
„ Postages			58 9 9
„ Expenses:			
Annual Meeting 1947 (Balance).			68 4 9
Annual Meeting 1948 (on account)			121 7 10
„ General Expenses			18 8 5
„ Grants to Local Centres under Rule 35:			
Witwatersrand		46 11 6	
Cape of Good Hope		9 13 6	
Natal		5 18 6	
			62 3 6
„ Depreciation on Office Furniture			8 10 0
„ Pension—H. A. G. Jeffreys			90 0 0
			£1,293 7 6

Cr.

	£ s. d.	£ s. d.
By Annual Subscriptions	966 13 0	
„ Arrear Subscriptions	69 0 0	
„ Associates' Fees	19 0 0	
„ Students' Fees	1 11 6	
		1,056 4 6
„ Interest:		
From Endowment Fund	134 11 5	
United Building Society, St. Andrew's Branch Savings Account	19 19 0	
Post Office Savings Bank Account	1 1 1	
		155 11 6
„ Balance, being excess of Expenditure over Income for the year ended 31st May, 1948		81 11 6
		£1,293 7 6

We report that, to the best of our knowledge and belief and on the information supplied to us, the above account reflects a true statement of the income and expenditure of the Association for the year ended 31st May, 1948.

Johannesburg,
16th June, 1948.

ALEX. AIKEN & CARTER,
Auditors.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

LIBRARY ENDOWMENT FUND.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY, 1948.

Dr.	£ s. d.	Cr.	£ s. d.
To Balance, transferred to Library Binding and Equipment Account	73 17 11	By Interest Received	73 17 11
	£73 17 11		£73 17 11

BALANCE SHEET AT 31st MAY, 1948.

	£ s. d.			£ s. d.
Amount due to General Fund	3 17 11	Investments :		
Accumulated Funds		£2,000 City of Johannesburg $3\frac{1}{2}\%$ Local Registered Stock, 1965 —at cost	1,970 0 0	
Balance at 31st May, 1947	2,164 11 6	United Building Society, St. Andrew's Branch—Savings Account	198 9 5	
				2,168 9 5
	£2,168 9 5			£2,168 9 5

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
ENDOWMENT FUND.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY, 1948.

Dr.	£ s. d.	Cr.	£ s. d.
To Interest, as per contra, transferred to General Fund	134 11 5	By Interest Received	134 11 5
,, Balance, transferred to Accumulated Funds ..	51 0 0	,, Life Membership Subscriptions	51 0 0
	£185 11 5		£185 11 5

BALANCE SHEET AT 31st MAY, 1948.

	£ s. d.	£ s. d.		£ s. d.	£ s. d.
Accumulated Funds:			Investments in Hands of Trustees.		
Balance at 31st May, 1947 ..	3,387 14 5		Cape Town Municipality 3¾% Stock—No. 145	1,150 0 0	
Add Amount transferred from Income and Expenditure Account	51 0 0		Cape Town Municipality 4% Stock—No. 140	300 0 0	
		3,438 14 5	Cape Town Municipality 5% Stock—No. 68	240 0 0	
			Cape Town Municipality 5% Stock—No. 120	800 0 0	
			Port Elizabeth Municipality 3½% Stock—No. 9	100 0 0	
			Cape of Good Hope Savings Bank	821 13 4	
					3,411 13 4
			Amount due from General Fund		27 1 1
		£3,438 14 5			£3,438 14 5

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

BRITISH ASSOCIATION MEDAL FUND.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY, 1948.

Dr.	£ s. d.	Cr.	£ s. d.
To Balance transferred to Accumulated Funds ..	19 7 5	By Interest Received	19 7 5
	£19 7 5		£19 7 5

BALANCE SHEET AT 31st MAY, 1948.

	£ s. d.	£ s. d.		£ s. d.	£ s. d.
Accumulated Funds :			Investments in hands of Trustees :		
Balance at 31st May, 1947 ..	544 16 3		£450 Union of South Africa $3\frac{1}{4}$% local Registered Stock 1948/1958	450 0 0	
Add Amount transferred from Income and Expenditure Account	19 7 5		Post Office Savings Bank ..	114 3 8	
		564 3 8			564 3 8
		£564 3 8			£564 3 8

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SOUTH AFRICA MEDAL FUND.

Dr. INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MAY, 1948. Cr.

	£ s. d.		£ s. d.
To Expenses in connection with 1948 Award ..	12 1 6	By Interest Received	52 13 0
,, Amount of Award, 1948	40 11 6		
	£52 13 0		£52 13 0

BALANCE SHEET AT 31st MAY, 1948.

	£ s. d.		£ s. d.
Accumulated Funds		Investments in Hands of Trustees :	
Balance at 31st May, 1947	1,755 18 5	Fixed Deposit, South African Permanent Mutual Building and Investment Society	1,755 18 5
	£1,755 18 5		£1,755 18 5

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Report of the Honorary Librarian for the Year ended May 31, 1948.

The Association's Library is housed in the Library of the University of the Witwatersrand, Johannesburg. The collection includes about 4,400 volumes and 279 different titles are received currently.

Exchange of Publications.—During the year the following new names have been added to the free mailing list:—

British Interplanetary Society, London.
Launceston, Tasmania. Queen Victoria Museum and Art Gallery.
Melbourne. National Museum of Victoria.
Suid-Afrikaanse Akademie vir Wetenskap en Kuns, Pretoria.

The following societies and institutions have resumed the exchange relations which were interrupted by the war, and their publications are again being received currently.

Denmark:

K. Danske videnskabernes selskab (*Biologiske meddelelser*; *Mathematisk-fysiske meddelelser*; *Skrifter*).

Holland:

Nederlandsche dierkundige vereeniging (*De Biologie van de Zuiderzee*).

Sweden:

K. Svenska vetenskapsakademien (*Arkiv för matematik astronomi och fysik*; *Arkiv för botanik*; *Arkiv för Kemi, mineralogi och geologi*; *Arkiv för zoologi*; *Arsbok*; *Handlingar*).

At the request of the Geological Society of South Africa, a complete set of the *South African Journal of Science* from Volume 29, 1932 to Volume 42, 1945 was presented to the Statny Geologicky Ustav, Czechoslovakia, as a contribution towards the rebuilding of their Library which was destroyed during the war.

Binding.—A start has been made with the binding of the periodicals which remained unbound during the war period, and 240 volumes were bound during the past year at the cost of £160.

Donations from the following are gratefully acknowledged:—

Clerk of the House, Legislative Assembly, Salisbury, S. Rhodesia.
Parliamentary papers C.S.R. 1947.

Mrs. J. F. Solly.
South African Journal of Science. Vols. 42, 43.

New Titles Received:—

British Interplanetary Society.
Bulletin. 2, 1947*
Journal. 6, 1947*

Geological Society of London.
Abstract of proceedings. 1940/41*

Launceston, Tasmania. Queen Victoria Museum and art gallery.
Records. 1, 1946*

Natuurwetenschappelijk tijdschrift. Ghent.
29, 1947*

Studia botanica cechoslovaca. Prague.
7, 1946*

Tydskrif vir wetenskap en kuns.
7, 1947*

Issues.—During the period September 1947 to May 1948, that is, from the time statistics have been kept, up to date, a total of 50 volumes or parts have been borrowed from the Association's library.

For a Catalogue of serial publications in this Library, and Supplement, see this *Journal*, vol 30, p.xxv—xxix, and vol 34, p.xxxiv—xxxvii. Subsequent accessions are listed in the Annual Report. Holdings appear also in the *Catalogue of Union Periodicals* and forthcoming Supplement.

(Sgd.) P. FREER,
Hon. Librarian.

University of the Witwatersrand, Johannesburg.
10th June, 1948.

SUID-AFRIKAANSE GENOOTSKAP VIR DIE BEVORDERING VAN DIE WETENSKAP.

Verslag van die Ere-Bibliotekaris vir die Jaar Geëindig 31 Mei 1948.

Die Genootskap se Biblioteek word in die Biblioteek van die Universiteit van die Witwatersrand, Johannesburg, gehuisves. Die versameling bevat omtrent 4,400 bande en 279 verskillende titels word lopend ontvang.

Ruiling van Publikasies.—Gedurende die afgelope jaar is die volgende nuwe name by die vrye poslys bygevoeg :—

British Interplanetary Society, London.
Launceston, Tasmania. Queen Victoria Museum and Art Gallery.
Melbourne. National Museum of Victoria.
Suid-Afrikaanse Akademie vir Wetenskap en Kuns, Pretoria.

Die volgende verenigings en institute het weer die ruiling van hul publikasies wat nie gedurende die oorlog gestuur kon word nie hervat, en dié word nou lopend ontvang.

Denmark :

K. Danske videnskabernes selskab (*Biologiske meddelelser* ; *Mathematisk-fysiske meddelelser* ; *Skrifter*).

Holland :

Nederlandsche dierkundige vereeniging (*De Biologie van de Zuiderzee*).

Sweden :

K. Svenska vetenskapsakademien (*Arkiv för matematik astronomi och fysik* ; *Arkiv för botanik* ; *Arkiv för Kemi, mineralogi och geologi* ; *Arkiv för zoologi Arsbok* ; *Handlingar*).

Op versoek van die Geologiese Vereniging van Suid-Afrika, is 'n volledige stel van die *Suid-Afrikaanse Joernaal van Wetenskap*, vanaf bd. 29 (1932) tot bd. 42 (1945), aan die Statny Geologicky Ustav, Tsjeggo-Slowakye geskenk, as 'n bydrae tot die heropbou van hulle biblioteek wat tydens die oorlog vernietig is.

Inbind van Boeke.—'n Begin is gemaak met die inbind van die tydskrifte wat gedurende die oorlog maar oningebind gebly het, en 240 bande is ten koste van £160 ingebind.

Geskenke van die volgende word dankbaar erken :—

Clerk of the House, Legislative Assembly, Salisbury, S. Rhodesia.
Parliamentary papers C.S.R. Series 1947.
Mrs. J. F. Solly.
South African Journal of Science, Vols. 42, 43.

Nuwe Titels Ontvang :—

British Interplanetary Society.
Bulletin. 2, 1947*
Journal. 6, 1947*
Geological Society of London.
Abstract of proceedings. 1940/41*
Launceston, Tasmania. Queen Victoria Museum and Art Gallery
Records. 1, 1946*
Natuurwetenschappelijk tijdschrift. Ghent.
29, 1947*
Studia botanica cechoslovaca. Prague.
7, 1946*
Tydskrif vir wetenskap en kuns. 7, 1947*

Uitlenings.—Gedurende die tydperk September 1947 tot Mei 1948, d.w.s. vandat statistieke gehou word, tot nou toe, is 'n totaal van 50 bande of dele, uit die Vereniging se biblioteek geleen.

Vir 'n Katalogus van periodieke publikasies in die Biblioteek, en Supplement, sien hierdie *Journal*, Band 30, p. xxv—xxix, en Band 34, p. xxxiv—xxxvii. 'n Lys van latere aanwinste word in die Jaarlikse verslag gegee, en 'n volledige lys verskyn ook in die *Catalogue of Union Periodicals* en daaropvolgende byvoegsel.

(Get.) P. FREER.
Ere-Bibliotekaris.

Universiteit van die Witwatersrand, Johannesburg.
10 Junie 1948.

In Memoriam.

JAN HOFMEYR

In my long experience of public life I came to know many great men, and it is my deliberate opinion that Jan Hofmeyr was among them and well up among them. His distinction lay, not in any single characteristic, but in a combination of many outstanding qualities that went to form his brilliant mind.

He chose the hardest and most thankless career, that of a politician. Had he remained in the academic field, in which he had such a unique record in his youth, he would have become a scholar and philosopher of international repute. Had he chosen the field of science, there is no knowing to what rank he might have attained.

Though not a scientist by profession, Jan Hofmeyr was deeply interested in science, and he kept as near abreast of scientific development, as a man of his varied duties and activities could afford. His great address to the international science congress at Cape Town in 1929, when he was President of the South African Association, will long be remembered. His plea that Africa should be regarded "as the world's most significant laboratory for human relationships"—"as it is the Continent which offers the richest opportunities to those who would investigate racial problems in the true spirit of science, and so discover the solutions which may yet enable a clash to be averted, and the threat to our civilisation which it implies to be dispelled". Prophetic words, which we would do well to bear in mind in these days when the claims of human rights resound from international platforms, whilst mutual ill-will between races and classes grows apace.

It was Jan Hofmeyr's conviction that science should not be remote, but should be integrated with human concerns and social progress as a whole. While it is to the scientist that we look for the technical advancement of knowledge, the effectiveness with which his work is brought to fruition does depend, in large measure, on its aspect as a social service, and the inspiration it gives to those who are concerned

with human advance in its broadest aspects. Science has its mission for man in the truest sense, and is a most important part of the forces which build up our outlook, endeavour and spirit.

Hofmeyr always encouraged a South African outlook in science. He felt the distinctive features of this outlook to be freshness and breadth of view, receptivity to new illumination, and readiness to see old truths in new settings. He felt that for us in this subcontinent the Southern approach and aspect of science was a significant facet of science as a whole, and an instance of the working of the holistic principle in the universe.

It remains only to say that during his long service in the Government and in public life, Jan Hofmeyr always favoured a liberal policy by the State towards science.

Though officially he held the purse-strings tightly, he loosened them more readily when the appeal was made on behalf of some scientific institution or some form of research which he believed to be in the national interests. By his death, science has lost a true friend and a man who brought to the pursuit of politics, as of knowledge itself, the truly scientific mind and outlook. His loss, so early in life, is perhaps the saddest blow this young community has suffered for many years. It may take another generation before South Africa again produces such a brain, such a combination of intellectual and spiritual gifts, such a great humanist in the widest sense.

J. C. Smuts.

Note.—*The Rt. Hon. Jan Hendrik Hofmeyr, P.C., M.P., B.A., D.C.L. (Oxon.), M.A. (Cape), D.Sc. (Cape Town), Rhodes Scholar, Fellow Balliol Coll. (Oxon.), Hon. Master of Bench, Gray's Inn, London, Chancellor of Witwatersrand University.*

Born Cape Town 20th March, 1894. *Died Pretoria 3rd December,* 1948, *aged* 54.

Matriculated at Cape, aged 12, *graduated in Arts aged* 15, *Master of Arts, aged* 17, *Rhodes Scholar aged* 19, *Principal Witwatersrand Univ.* (1919-1923), *Administrator Transvaal* (1923-1928), *President, The Classical Association of South Africa (1927—1948), President, South African Association for the Advancement of Science (1928—1929), M.P., Johannesburg N.* (1929-1948), *Minister of Interior, Education, Public Health* (1933-39), *Finance* (1939-1948), *Deputy Prime Minister and Leader of Parliament.*

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THE FISHING INDUSTRY OF SOUTH AFRICA

BY

Dr. S. H. Skaife

Chairman,

Fisheries Development Corporation of South Africa Limited.

President's Address to the South African Association for the Advancement of Science at the Annual Meeting of the Association in Lourenço Marques, June, 1948

Introduction.—The difficult post-war years have taught us that the food resources of the world are barely sufficient for the growing population. Sir John Boyd Orr, the Director-General of the Food and Agriculture Organization of the United Nations, declared in an address to the National Fisheries Institute in New York early this year that we must step up the world food production by over 100 per cent. during the next twenty-five years if there is to be sufficient food for all the people. He went on to say that the biggest increases need to be made in the production of the more expensive foods—those rich in proteins, minerals and vitamins, and that "There is no better source of proteins and some vitamins than fish, and fish can be produced at less than half the cost, reckoned in terms of man-hours of work, required to produce pork, for example, which is one of the most easily produced sources of animal protein.".

Decreasing soil fertility and increasing population will force us to turn our attention more and more to marine sources of food. Of all the great natural resources of the world, including agriculture, mines, forests and fisheries, the last is the only one that is self-perpetuating and that can be greatly expanded at the present day. Yet the wealth of the seas, vast though it is, is not inexhaustible, as has been proved by over-fishing problems that have arisen in some parts of the world in recent years. Fortunately in South Africa, with our rich fishing grounds, our long coast-line and our absence of near neighbours, we have no serious over-fishing problem at present. Our immediate problem is how best we can exploit and at the same time conserve our marine resources. Such exploitation and conservation must be based on scientific knowledge, and I propose in this address to give a brief survey of the present position with regard to marine investigations in this country.

Historical.

The chief steps in the development of marine investigations in South Africa have been as follows :—

1895: A beginning was made when the late Professor J. D. F. Gilchrist was appointed marine biologist by the Government of the Cape Colony. He carried out valuable pioneer survey work by

means of a small vessel specially constructed for the purpose, the *Pieter Faure.*

1899: A commencement was made with the building of the marine biological station at St. James out of the profits made by the *Pieter Faure.*

1902: The building was completed at St. James and opened as "The Aquarium".

1905: The marine survey was discontinued owing to the depression and there is a gap until 1920, although Gilchrist continued to work on marine biological problems as Professor of Zoology at the South African College.

1908: The St. James Aquarium was transferred to the Trustees of the South African Museum and maintained by them until 1912 when it was retransferred to the Cape Provincial Administration.

1920: The Marine Biological Survey was reinstituted on a meagre basis. The Union Government contributed £3,000 per annum towards the cost and the two maritime provinces, Cape and Natal, together with a private firm, Messrs. Irvin & Johnson, subscribed a further £12,000. A former whaling vessel, the *Pickle,* was refitted to serve as a research vessel. Nineteen months' work by this vessel, at a cost of £17,000, opened up valuable trawling grounds on the west coast.

1924: The Union Government assumed full responsibility for marine investigations and the sum of £10,000 was voted for the purpose.

1925: The Fishing Harbours Commission was appointed to enquire into and report upon the construction and improvement of fishing harbours, and the opening and development of ports for the accommodation of trawlers and larger fishing vessels. This committee issued an important, informative report in eight volumes between 1926 and 1928.

1926: On the death of Professor Gilchrist, Dr. C. von Bonde was appointed his successor as Director of the Marine Biological Survey.

1929: The Division of Fisheries and Marine Biological Survey was established with an annual vote of £20,000 and Dr. C. von Bonde was appointed as the first Director of Fisheries. The *Pickle* was replaced by a larger vessel, the *Africana,* specially designed and built for marine investigations.

1934: The Board of Trade and Industries issued its useful Report No. 180 on "The Fishing Industry" and made some far-reaching recommendations.

1939: On the outbreak of war the *Africana* was taken over by the naval authorities and there was a break in marine investigations until the end of the war.

1940: The Division of Fisheries left the old Aquarium at St. James and took up its quarters in new premises at Sea Point.

1944: The Fisheries Development Corporation of South Africa Limited was established by the Government, with a capital of £1,000,000, to co-operate with and assist private enterprise in developing the industry along sound, rational lines, and to provide social amenities, such as housing, health services, insurance schemes, community centres, and so on, for fishermen and their families.

1947: The Fishing Industry Research Institute was founded at Cape Town, with an annual income of £10,000, half of which is subscribed by the industry and half by the Council for Scientific and Industrial Research. The Institute is to deal with the many technological problems that confront the industry and Dr. G. M. Dreosti is the Director.

The *Africana* was returned to the Division of Fisheries during the year and the marine survey is now being continued, but she is to be replaced next year by a larger vessel, the *Africana II* which is now being built. The new vessel will be 200 feet long and will cost £150,000. The annual vote for the Division of Fisheries and Marine Biological Survey now amounts to a little over £32,000.

The Division has two small patrol vessels in commission at the present time, the *Palinurus* and the *Schipa*, which are engaged mainly in patrolling and surveying the crawfish grounds of the west coast.

STATISTICS.

Although the position to-day is a considerable improvement on that of fifty years ago, when Gilchrist was working alone, with inadequate facilities and equipment, it cannot be regarded as satisfactory. We still lack basic, essential information about the commonest of the fish upon which the industry depends and we have no statistics by which we may judge whether over-fishing in taking place or not and from which we can form some idea of the future prospects of the industry.

This question of statistics is so important that it is necessary to examine the position in some detail. Fifty years ago Gilchrist commenced to collect statistics with the aid of people stationed at the different fishing centres, some of whom worked voluntarily and others were paid a few shillings a month for sending in the returns. Thus we have incomplete figures of the catches by inshore fishermen from 1897, but there are no statistics at all concerning the catches by trawlers that commenced work at the turn of the century.

After 1905 the provincial administrations of the two maritime provinces took over the collection of statistics and they carried on the same lines as those inaugurated by Gilchrist. The almost valueless, incomplete returns of fish caught by inshore fishermen were continued until 1929, when the Division of Fisheries took over.

Despite repeated representations by the Director of Fisheries, no financial provision was made for the collection of statistics on an adequate scale. The record of the catches by inshore fishermen

was discontinued in 1930, but monthly returns sent in by the trawling companies operating at Cape Town, Mossel Bay, Port Elizabeth and East London were listed, and this has been continued to date.

From 1932 to 1939 G. E. Greening, at that time Superintendent of the Fish Market at Cape Town, kept statistics of the landing of fish in the harbours of the Cape Peninsula by fishing craft other than trawlers.

Apart from these figures, we have no statistics at all to guide us, nothing concerning the catch per unit of effort, the distribution of fish in size-classes, the seasonal fluctuations, and so on. With the rapid expansion of the fishing industry that is going on to-day, this lack of essential information is becoming ever more serious.

Recently it has been proposed that there should be a levy of a fraction of a penny per pound on all fish caught and that part of the money so raised should be used for the collection of statistics. A levy of only one-fortieth of a penny on every pound of fish landed would yield an income of about £20,000 per annum. This would be sufficient to pay not only for the collection of statistics but also for inspection services, as well as for the contributions the industry is making at present towards the upkeep of the Fishing Industry Research Institute. It is to be hoped that the Government and the industry will accept this proposal and that the collection of adequate, reliable statistics will be undertaken as soon as possible.

THE GROWTH OF THE FISHING INDUSTRY.

Gilchrist estimated the extent of our fishing grounds at 112,000 square miles, an area larger than that of the Transvaal, and Von Bonde has increased this estimate to 150,000 square miles because of the greater range of some of the fishing craft operating to-day. More than four-fifths of our fishing industry is based on the west coast, from Walvis Bay in the north to Cape Town in the south. In the cold waters off this coast such valuable fish as the pilchard, stockfish, snoek, maasbanker and harder, as well as the crawfish, abound. There are valuable trawling grounds along this coast, from the 13- to the 300-fathom line, rich in fish but much of it unexploited at present.

On the south coast the Agulhas Bank stretches from Cape Agulhas to Port Elizabeth and, although the trawling grounds are somewhat patchy and broken up by rocky and coral bottom, they are also rich in fish, particularly the valuable sole, *Austroglossus pectoralis*. There are small trawling grounds off East London, but none at all in Natal waters, except the deep-sea crawfish beds at about 250 fathoms off Durban that are not fished at all at present.

The rapid growth of the fishing industry may be summarized as follows :—

1900: Prior to the experimental trawling carried out by the *Pieter Faure* under Gilchrist's direction from 1899, all the fish landed are caught by line and surface nets operated from small sailing and

rowing boats. The total weight of fish caught annually round the shores of Cape Colony in those days was somewhere in the region of 10,000,000 pounds, valued at £50,000. Natal waters have never contributed more than 10 per cent. of the total landings, therefore we can estimate that about 11,000,000 pounds, valued at £55,000, was the approximate annual total taken from our waters at the turn of the century.

Gilchrist estimated the value of the boats and gear engaged in the fishing industry at the Cape in 1899 at £13,000.

The total catch increased to 20,000,000 pounds in 1900, after commercial trawling had started on a small scale, valued at about £100,000. In this year there were seven trawlers and 361 sailing and rowing vessels engaged in fishing round our coast and they were operated by 1,800 fishermen.

1934: The Board of Trade Report No. 180, "The Fishing Industry", estimated that the capital invested round our whole coast, including fishing craft, canning plant, cold stores, etc., was "not far short of a million pounds". The total annual catch had increased to 45,000,000 pounds, valued at £320,000. There were 17 trawlers, 307 steam and motor vessels other than trawlers, and 1,134 sailing and rowing) boats—1,458 craft altogether—operating at this time, valued at £300,000 and keeping 6,000 fishermen employed.

1947: F. P. Spooner, the General Manager of the Fisheries Development Corporation of South Africa Limited, has recently made a careful computation of the amount of capital invested in the industry, and his figures given below may be accepted as reflecting the true position to-day:—

YEAR	TRAWLING INTERESTS.		INSHORE INTERESTS.		TOTALS	
	Subscribed Capital † Reserves.	Market Value	Subscribed Capital † Reserves.	Market Value	Subscribed Capital † Reserves.	Market Value.
	£	£	£	£	£	£
1939	950,000	1,575,000	725,000	775,000	1,675,000	2,350,000
1944	1,100,000	2,050,000	1,175,000	1,380,000	2,275,000	3,430,000
1947	1,550,000	3,150,000	3,765,000	6,950,000	5,315,000	10,100,000

These figures show a remarkable growth in the last few years—a threefold increase in the market value in four years. The jump in the value of the inshore fishing is especially striking—a ninefold increase in ten years, due mainly to the rapid growth of the canning and processing plants along our west coast!

There are no reliable figures available concerning the catches by inshore fishermen to-day, but the estimated total weight of all fish caught is well over 200,000,000 pounds per annum, valued in the unprocessed state at about £2,500,000. Trawled fish accounts for about 60,000,000 pounds of this at present.

At the beginning of the current year there were 30 steam trawlers, 7 motor trawlers, 2 steam line-boats, 699 motor boats, 238 sailing and rowing boats over thirteen feet in length, and 1,243 dinghies under thirteen feet in length, a total of 2,219 fishing craft, worth about £2,000,000 at today's prices.

It is estimated that there are 5,000 fishermen engaged in the industry, with another 4,000 persons employed in the various canning and processing plants. Altogether, between 40,000 and 50,000 men, women and children are dependent on the fishing industry for their livelihood at the present time.

THE MAIN SOURCES OF SUPPLY.

Cape Town is by far the most important of the fishing centres. Of the 60,000,000 pounds of trawled fish caught annually, about 50,000,000 pounds are landed at Cape Town, 4,000,000 at Port Elizabeth, 4,000,000 at East London and 2,000,000 at Mossel Bay.

Stockfish (*Merluccius capensis*) is much the most important of our food fishes. Out of the 60,000,000 pounds caught by trawlers, no less than 40,000,000 to 45,000,000 pounds consists of stockfish. The remainder is made up of pangas (*Pterogymnus laniarius*), 4,000,000 to 5,000,000 pounds, soles (*Austroglossus pectoralis* and *A. microlepis*), 4,000,000 to 5,000,000 pounds, kabeljou (*Sciaena hololepidota*), about 2,000,000 pounds, kingklip (*Genypterus capensis*), 1,000,000 to 2,000,000 pounds, and the remaining two or three million pounds are made up of geelbek (*Atractoscion aequidens*), jacopever (*Sebastichthys capensis*), John Dory (*Zeus capensis*), maasbanker (*Trachurus trachurus*), silverfish (*Polysteganus argyrozona*), steenbras (*Petrus rupestris*), white stumpnose (*Austroparus globiceps*), and a few others of minor importance.

Greening's figures show that, during the eight years from 1932 to 1939, an average of about 23,000,000 pounds of fish was landed annually at harbours in the western Cape by inshore fishermen. If we estimate another 17,000,000 pounds for all the other fishing centres round our coast, we get 40,000,000 pounds as the total inshore catch and this, together with the trawled fish, makes a total of 100,000,000 pounds per annum. This figure does not include pilchards, crawfish and sharks.

Pilchards have sprung into great prominence during the past three or four years. Before the war they were almost completely ignored, only a small quantity being caught each year for use as bait. To-day about 70,000,000 pounds are taken annually for canning and processing and this figure is rising rapidly. Thus, from a quantitative point of view, in a remarkably short time the pilchard (*Sardina sagax*) has become the most important of all our fish.

About 25,000,000 pounds of crawfish (*Jasus lalandii*) are caught each year in the cold waters off our west coast. About two-thirds of this weight is at present discarded or utilized only to a small extent for the manufacture of meal or for use as fertilizer.

Most of the 5,500,000 pounds of sharks' flesh caught each year is thrown away at present as only the livers are utilized for the extraction of vitamin oil. A little of the flesh is converted into shark biltong but this has scarcely progressed beyond the experimental stage. Because of the popular, irrational prejudice against sharks' flesh, much valuable food is being wasted.

The following table shows the chief sources of supply, in order of quantitative importance. The figures given are approximations based on the inadequate statistics available :—

Fish.	Weight caught annually.	Value.
	lb.	
1. Pilchard (*Sardina sagax*)	70,000,000	500,000
2. Stockfish (*Merluccius capensis*)	45,000,000	750,000
3. Crawfish (*Jasus lalandii*)	25,000,000	720,000
4. Snoek (*Thyrsites atun*)	20,000,000	500,000
5. *Maasbanker* (*Trachurus trachurus*)	15,000,000	90,000
6. Soupfin shark (*Galeorhinus canis*)	5,500,000	300,000
7. Soles *Austroglossus pectoralis* and *A. microlepis*)	5,000,000	187,500
8. Panga (*Pterogymnus laniarius*)	5,000,000	62,500
9. Kabeljou (*Sciaena hololepidota*)	4,500,000	110,000
10. Geelbek (*Atractoscion aequidens*)	3,000,000	50,000
11. Silverfish (*Polysteganus argyrozona*)	2,500,000	40,000
12. Harder (*Mugil capito*)	2,500,000	17,500
13. Kingklip (*Genypterus capensis*)	2,000,000	50,000
14. Yellowtail (*Seriola lalandii*)	750,000	22,500
15. Mackerel (*Scomber colias*)	750,000	4,500
16. Hottentot (*Pachymetopon blochi*)	500,000	8,750
17. Steenbras (*Petrus rupestris*)	450,000	8,000
18. White Stumpnose (*Austrosparus globiceps*)	400,000	8,500
19. Elf (*Pomatomus saltator*)	300,000	4,500
20. Jacopever (*Sebastichthys capensis*)	250,000	4,000
21. John Dory (*zeus capensis*)	200,000	4,000
22. Red Stumpnose (*Chrysoblephus gibbiceps*)	150,000	3,500
23. Steentjie (*Spondyliosoma emarginatum*)	150,000	1,500
24. Bonito (*Sarda Sarda*)	125,000	1,500
25. Red Roman (*Chrysoblephus laticeps*)	75,000	1,250
Totals	209,100,000	3,450,000

THE PILCHARD (*Sardina sagax*).

Ten plants have been established along our west coast during the past three or four years for the conversion of pilchards into badly-needed oil and meal. Eight of these plants are situated in the St. Helena Bay area and two at Walvis Bay. The erection of the buildings and the installation of the machinery is not yet complete at some of them; but when all are working at full capacity they will deal with about 100,000 tons of pilchards and maasbankers annually. Between them, the plants are turning out at present about 5,000 tons of meal and 250,000 gallons of oil per annum. In addition, there are a number of canning plants that handle about 5,000,000 pounds of pilchards annually.

Thus the annual catch of pilchards off our west coast has suddenly leaped from very little in 1942 to about 70,000,000 pounds in 1948, and projected developments are likely to treble and quadruple this amount in the not-too-distant future. Although capital to the extent of several hundreds of thousands of pounds has been and is being invested in buildings and plant for the exploitation of this valuable fish, we know very little about it indeed—we are, in fact, dangerously ignorant.

Marchand (1935) states that huge shoals appear every year at Walvis Bay from October to January, Port Nolloth from February to May, Saldanha Bay from April to June, Table Bay from April to June, False Bay from June to July, Mossel Bay from May to July, and he adds that these periods are subject to a certain amount of variation within narrow limits from year to year. Barnard (1947) says that shoals may be expected to arrive inshore at Port St. Johns every year between the 3rd and 10th June. Large shoals appear off the coast of Natal about June every year but it is not known how long they stay or where they go.

According to Barnard (1947) the Californian pilchard is identical with our own, although it has a different specific name (*Sardina caerulea*). Because of its great economic importance, the Californian species has been extensively studied by American biologists and we can, to a certain extent, make up for our own lack of knowledge by turning to the American investigations for enlightenment.

The Californian pilchard fishery is similar to our own, but they have had had thirty years' start of us there. The fishery off the Californian coast commenced in 1915 and grew rapidly until, by 1938, the annual catch reached the enormous total of one thousand million pounds. Already, however, ominous signs of over-fishing and depletion were apparent, but nothing was done about it, despite the warnings of biologists.

In 1937-38 the Californian fishermen were catching less than half what they had taken six seasons before per unit of effort. The length of life of the pilchard is reckoned to be ten years plus, but by 1938 few were surviving in Californian waters beyond their fourth and fifth years. There was a steady decrease in the size of the fish taken from 1938 onwards. To-day, in spite of larger boats and better gear, in spite of the use of aeroplanes for spotting the shoals, the annual catch has fallen off alarmingly and the industry is faced with a crisis.

Various remedial measures have been proposed, including the following: no permits to be issued for one or more seasons for the conversion of pilchards into oil and meal; stricter close seasons to be enforced; the proclamation of closed areas as sanctuaries; a larger mesh to be used in the nets so that immature fish may escape; a limit to be set on the number of plants and on the number and size of the boats engaged in the industry.

The most practical of the measures urged seems to be the imposition of a ceiling on the total amount of fish to be caught annually—a type of control that has proved very effective in saving the Pacific halibut fishery. A limit of three hundred million pounds per annum has been proposed as the limit to be set on the Californian pilchard fishery, and this figure is of great interest to us in South Africa, for it is the figure that may be reached here in a few years' time.

The American investigations indicate that the pilchard moves up and down the Pacific coast, from California to Southern Alaska, a range of about 2,000 miles, and they are not found further than 300 miles from the shore. Despite the wide range of the fish, the chief spawning grounds are limited to a comparatively small area, some 200 miles long by 100 miles wide, off the coast of Southern California. The great majority of the mature fish migrate to this area and spawn when the temperature of the water is between 14° and 18° C. No eggs are laid when the temperature is 12° C. and lower. It is probable that a similar state of affairs will be found to hold good in the case of our pilchards and there are indications that the chief spawning grounds in South Africa are somewhere in the St. Helena Bay region.

The pilchard reaches maturity when it is between six and eight inches long and all are fully mature when nine inches long. An eight-inch female will lay about 90,000 eggs and a ten-inch about 150,000. The spawning season in Californian waters lasts from February to July, with a maximum in April and May. There are indications that the fish may spawn twice and even three times in one season. Investigations now being carried out by I. D. Hattingh (results not yet published) point to the same conclusion with regard to our own species.

The success of each year's spawning varies within wide limits, some years being good survival years and others very bad. This fluctuation gives rise to dominant size-groups on which much of the success of the fishery depends. There have been six such superabundant year-classes in the Californian fishery since 1915—the last, in 1939, being the mainstay of the industry during the war years. As soon as this class began to disappear the size of the annual catch dropped with alarming rapidity. At present we know nothing at all about good and bad survival years and size-groups as they affect our own fishery.

With regard to the food of the pilchard, it is known that, when young, they feed on copepods and other small organisms, but, as they grow older, the gill-rakers develop on their gill arches and they feed exclusively on diatoms and other microscopic plants and animals.

At present the scales that are removed from the pilchards in our canning and processing plants are allowed to run away into the sea in a silvery stream of waste. In America the scales are collected and sold for manufacture into pearl essence and into a special type of fire-fighting foam. During the 1946 season in California 2,500,000

pounds of pilchard scales were sold for $600,000. Something like half-a-million pounds of scales are thrown away every year in South Africa.

The rapid expansion of the pilchard fishery off our west coast is an excellent thing, but the position needs close watching to prevent a crisis such as has developed in the Californian industry. Investigations carried out in our own waters on an adequate scale are urgently needed to provide us with basic, essential information. Sound administration of such a fishery can only be based on knowledge we do not at present possess—a knowledge of the migrations, habits, food, growth and spawning of the fish, of the fluctuations from year to year due to good and bad survival seasons, of the variation in the catch per unit of effort, of the length of time a given size-group can be detected in the fishery, of the proportion of large fish to smaller sizes, and so on. Only when we know about such things and about the variations in temperature, salinity, currents and plankton and their effects on the fish, shall we be able to predict with any confidence the future of the fishery five or six years ahead and to form any judgment whether there is over-fishing or not.

THE STOCKFISH (*Merluccius capensis*).

The amount of stockfish taken by trawlers in our waters has increased very rapidly in recent years. It grew from a little over 10,000,000 pounds in 1932 to 44,000,000 pounds in 1946. At the same time, catches by inshore fishermen seem to have fallen off rapidly. Greening's figures show that the weight dropped steadily from 3,875,230 pounds in 1932 to 1,116,000 pounds in 1938. Thus during the period when the catch of trawled fish was more than doubled, the catches of the inshore fishermen fell to less than one-third. It is impossible to say whether the increased intensity of trawling has anything to do with the falling off of the catches closer to the shore.

Despite the great importance of the stockfish, no detailed study of it has yet been made. We are not even sure whether or not it is identical with the European hake (*Merluccius vulgaris*). Barnard considers that it may be, but certainty can only be reached by comparison of numbers of specimens from both regions.

Roux (1947) carried out some preliminary investigations on the growth-rate of this fish and he found that the males increase in length by about 3¾ inches per annum, whilst females add about 4½ inches to their length each year. This is a higher rate of growth than in the case of the European hake, as found by Hickling (1934) who says that females grow 3½ inches per year and the males more slowly than the females from their third year onward.

The stockfish is a comparatively slow grower. According to Hickling, the European hake doubles its weight each year from three to seven years of age and it is probable that a similar increase takes place in the case of the stockfish. The male hake in European waters is mature in its fourth year, when it is 11 inches long, but the

female does not reach maturity until she is about ten years old and 27 inches to 30 inches long.

Roux (1947) gives length-distribution curves of samples of 500 to 1,000 stockfish taken from single drags of trawlers working off Cape Town during 1942, 1944 and 1945, and he shows a peak of 19 inches for both sexes. This is a mesh-selection peak ; the net of two-inch bar, required by the regulations, prevents the escape of all fish 19 inches long and over. Smaller fish may or may not escape. Stockfish under 11 inches are seldom caught.

The taking of males of 19 inches and less is not serious because they are mature when about 11 inches long, but no female of 19 inches or less has had any chance to spawn and the capture of large numbers of immature females every year might have serious consequences.

Fifty years ago Gilchrist (1899) gave the average weight of stockfish caught as six pounds each. Roux and Molteno (1946) state that the average weight of cleaned (headed and gutted) stockfish caught to-day is only about 3½ pounds. Of the stockfish caught by the *Pieter Faure* during experimental trawls in 1903, 90 per cent. were over 24 inches long, whilst only ten per cent. were less than two feet. To-day the average length of the catch is about 19 inches. We have too few statistics to be able to draw any reliable conclusion, but the figures quoted above indicate a significant falling off in the average size of the fish caught—a state of affairs that is even more marked in the hake fishery of Great Britain.

The bulk of the catch to-day comes from trawling grounds known as the West Ground, to the west and north-west of Cape Town, about forty miles out, between the 100- and 200-fathom lines, over an area about thirty miles long by ten miles wide. Roux, in a paper not yet published, has made a study of the catches of stockfish on the West Ground from 1940 to 1947, and he concludes that "It appears improbable that the hake fishery on the West Ground has exceeded the limits of sound fishing practice. This conclusion is tentative and does not obviate the necessity for more extensive and sustained investigations, which may confirm or disprove it." Nobody who has studied the available facts will quarrel with this conclusion, but it is well to remember that the fishing on the West Ground has doubled in intensity during the past year. There are extensive grounds further to the north that have so far not been exploited at all, with the exception of a little trawling on what is known as the North Ground off Port Nolloth.

Roux and Molteno (1946) show that the catches of stockfish per trawler per day vary between fairly wide limits, reaching a maximum usually from March to May and dropping to a minimum in September. They ascribe the differences in the catches and in the average size of the fish to migratory movements. There is a movement away from the grounds into deeper water from March to September and a return movement back to the grounds from September to March. The larger fish (six pounds and over) begin to

return earlier than the small and medium-sized fish and they are concentrated on the grounds by October, whence they pass closer inshore in November and December.

This movement of the mature fish is obviously connected with spawning and it indicates that the main spawning grounds may be in shallower water and closer inshore than the trawling grounds. The fish seem to spawn during the landward migration in the spring and the large fish migrate back again over the trawling grounds and out into deeper water beyond from January to April.

Roux (in a paper still in manuscript) assumes that the major movements of the stockfish are inshore and offshore, as is the case with hake in other parts of the Atlantic. Large stockfish, consisting mainly of females, appear to move more rapidly and further than the others, and their migrations to and away from the grounds normally precede those of the medium and small fish. The inshore movement takes place in the spring and summer and the fish return to deeper waters in autumn and winter.

Roux and Molteno (1946) state that the stockfish spawns from September to January and they base their assumption on the landings of stockfish roes at Cape Town. Only large, ripe roes are brought in and the spawning season may be assumed to cover the period when the number of roes landed is rapidly decreasing, due to the shedding of ova by the females. The quantity of roes landed reaches a peak in August and then drops rapidly to December, beginning to rise steeply again in the following May and June. According to Hickling, a female hake lays half-a-million to two million eggs annually.

Hickling (1935) states that the eggs and fry of the hake are carried by currents some distance from the spawning grounds and the survival rate depends largely on the temperature of the water and the amount of food available in the form of plankton. We know little or nothing about the conditions in our own seas that result in a good or bad survival year. The European hake is said to be pelagic for the first two years of its life and it is almost certainly the same with the stockfish ; that is probably the reason why few small fish less than eleven inches in length are ever caught in the nets.

Rattray (1947) has made a study of the food cycle of the stockfish and his findings correspond closely with those of Hickling on the food habits of the European hake. The stomach contents of 1,450 stockfish, trawled off Cape Town, were examined by Rattray and he found the principal types of food to be species of shrimplike crustaceans (*Mysidacea* and *Euphausiacea*) that swim in mid-water and near the surface, small deep-sea fish (*Myctophum* and *Maurolicus*), small stockfish, rat-tails (*Macrurids*), cephalopods, and to a lesser extent maasbankers (*Trachurus trachurus*). The cycle may be represented thus : plankton, copepods, small fish, mysids and euphausiids, small and medium-sized stockfish, maasbankers, macrurids, cephalopods, large stockfish. Rattray found that the

stockfish are great cannibals and that small individuals form an important part of the food of the larger fish.

As Gilchrist pointed out fifty years ago, few stockfish are caught in the trawls at night. This is because they leave the bottom during the hours of darkness and swim up into mid-water and nearer the surface to feed. During the day they lie at the bottom and this is the time when they are caught.

Gilchrist (1924) described a parasitic protozoon, *Chloromyxum thyrsites*, that causes a serious disease among snoek (*Thyrsites atun*). Rees Davies and Beyers (1947) report that this, or a closely-allied parasite, is responsible for a diseased condition of stockfish that gives rise to white spots in smoked fillets. There is no visible sign of infection in the stockfisn until after the flesh has been smoked. The white spots, on pressing, exude a milky fluid containing myriads of the spores of the parasite. Rees Davies and Beyers discovered that the infected muscle fibres fluoresce under ultra-violet light through Wood's glass and by using this method of determination they found that 70 per cent. of 660 stockfish examined were infected. As these or closely-allied parasites infect large numbers of snoek, John Dory and other fish, as well as stockfish, it is important that a detailed study should be made of them as soon as possible.

Molteno and Rapson (1939), Rapson, Schwartz and Van Rensburg (1944), Van Wyk (1944) and Roux and Molteno (1946) have studied the variations in the oil and vitamin A contents of the stockfish. Their results may be briefly summarized as follows: 3 per cent. of the total lipid material in the fish was found in the head, 30 per cent. in the body (flesh and viscera), and 67 per cent. in the liver. Of the vitamin A, about 70 per cent. is in the liver and the remaining 30 per cent. chiefly in the intestinal fat. The percentage of vitamin A in both the liver and visceral oils, as well as the total vitamin A per fish, rose steadily with an increase in size, but this general increase in vitamin A is subject to seasonal fluctuations.

Both liver and viscera showed a maximum percentage of oil from April to June and a minimum from October to November. The vitamin A potency of the oil showed an opposite trend, reaching a maximum from October to November and a minimum from April to June. These variations in the oil and vitamin A content are obviously closely linked with the sexual cycle of the fish, the fat content rising as the gonads ripen and reaching a maximum just when the spawning season commences, whilst the vitamin A content is highest when the gonads are least active.

Stockfish livers form the chief source of vitamin oil. No less than 1,835,627 pounds of livers were landed by trawlers in 1947. From data given by the authors just mentioned it would seem that the average oil content of the livers is about 30 per cent., therefore the yield should be 550,688 pounds of oil, which, at 9.3 pounds to the gallon, is about 59,000 gallons from the quantity of livers stated above. The amount of oil extracted from the livers of

sharks caught around our coast is estimated at 43,000 gallons in 1947.

THE CRAWFISH (*Jasus lalandii*).

Six million pounds of crawfish tails may be canned or frozen annually for export from the Union of South Africa. This is the ceiling fixed in 1947 by the Government, in consultation with the fishing industry, in order to save the valuable crawfish beds off our west coast from over-exploitation.

According to Van Rensburg (1948) the tail of a large crawfish constitutes some 28 per cent. of the total weight, whereas that of a small specimen is about 35 per cent. of the total. Assuming that the tail is, on the average, one-third of the total weight, 6,000,000 pounds of tails means that 18,000,000 pounds of crawfish are taken each year for the export trade alone. If we add to this another 2,000,000 pounds for the home market, which is small when compared with overseas trade, we get a total of 20,000,000 pounds. About 5,000,000 pounds more are caught off the shores of South West Africa.

Nobody can say yet whether the beds can stand this rate of exploitation or not. The crawfish are already afforded a certain amount of protection by the proclamation of sanctuaries where the catching of crawfish is prohibited in any manner or for any purpose. There are six such sanctuaries at present—four in the Cape Peninsula area, one at Saldanha Bay and another in St. Helena Bay. There are also regulations forbidding the taking of soft-shelled specimens, of females "in berry", and of individuals with a carapace-length of 3½ inches. Despite the two patrol boats, it would seem that these regulations are not enforced as strictly as is desirable.

The growth of the industry can be gauged by the fact that Gilchrist gave the total amount of crawfish caught in 1901 as 202,270 pounds. This amount had risen to 511,205 pounds by 1905, 15,000,000 pounds in 1932 and 25,000,000 pounds in 1947. The exports of crawfish have risen from 3,566,000 pounds of canned tails in 1924 to 5,156,000 pounds of canned and frozen tails in 1947.

More than half the total weight of crawfish caught is discarded at present, in the cephalothoraces and appendages that are dumped in the sea. A small quantity is converted into meal for poultry feed, and some is taken by farmers situated near the fishing centres and put on their land as fertilizer. The problem of the collection and conversion of this offal into badly-needed meal is a difficult one and is being investigated by the Fishing Industry Research Institute. The centres where the crawfish are caught are widely dispersed along the west coast and it would not pay to install plants for the making of meal at each of these centres, therefore some economic method or methods of drying and preserving the cephalothoraces must be devised so that the offal can be collected and transported to one or two centrally-situated points. Sun-drying is unsatisfactory and gives rise to an inferior meal. The hard shell

and soft flesh of the crawfish make the milling of the offal difficult and require a special type of plant.

Gilchrist (1913, 1916, 1918, 1920), Von Bonde and Marchand (1935) and Von Bonde (1936) have carried out investigations of the life history and habits of the crawfish at the Cape, and Hickman (1945, 1946) has studied the same species in Tasmanian waters. There are still, however, many serious gaps in our knowledge of this important crustacean. The commercial fishery is confined to the west coast, from Cape Point to Walvis Bay, between low-water mark and the 20-25 fathom line. Specimens are caught on the south coast as far east as Algoa Bay, but they are not found in any quantity or size. The crawfish is a typical inhabitant of the Laminaria zone of the cold water along the west coast.

There are indications that migrations on a fairly extensive scale take place. The crawfish are not evenly distributed throughout the whole area, and spots where they are abundant at one time may be almost devoid of them at another time. At certain times of the year male crawfish are found congregated in some areas and females in others, whilst at another season the males and females are found together. Gilchrist and Von Bonde started tagging experiments on a small scale some years ago but the work was dropped before any results of value were obtained. The migrations are apparently connected with feeding, moulting and mating and it is important that we should know more about them. The method at present in use in Australia of marking crawfish by punching holes of different shapes in the telson seems to be the simplest and most promising method of tagging them for migration studies.

According to Von Bonde and Marchand (1935) the number of eggs laid by the females varies with the size, "from about 3,000 to nearly 200,000". Hickman (1946) found by weighing and counting the eggs that a small female with a carapace-length of 3 inches (7.4 cms.) laid 68,650 eggs, whilst a large female with a carapace-length of 5 inches (12.4 cms.) laid 399,590 eggs. The figures given by Von Bonde (1936), from 3,000 in the smallest to about 20,000 in the largest are obviously too low and may be due to a misprint.

Von Bonde indicates that a female may spawn only every alternate year. He says:—"During the first sexual period, i.e., from birth to maturity of the female, the growth of the first generation of eggs is exceedingly slow, occupying anything up to five years . . . The eggs, when completely mature, are then laid . . . In about a year's time, or at the beginning of the summer following ovulation, a second period of growth ensues, and this is followed by a second interval of quiescence, usually in winter. At the beginning of the third season or cycle after ovulation, the ova undergo a last period of active growth and are then ready for extrusion." Later in the same paper he says:—"It is difficult to know whether a female will lay eggs every season at yearly intervals, for experiments conducted on females in captivity have not had the desired results, but it is quite possible that, as in the lobster, there is a biennial spawning period."

In Cape and Australian waters the main season for egg-laying is during the winter months, from May to August, but there seems to be a wide variation in different localities. Von Bonde and Marchand give the length of time taken by the eggs to hatch as from three to five months; Von Bonde (1936) states that the incubation period is about 95 days, and Hickman gives it as three to four months.

Gilchrist, Von Bonde and Marchand have tried to rear crawfish from the egg in the laboratory and they give detailed descriptions of the larval stages. Unfortunately they failed to rear the young through the later stages of metamorphosis, therefore we have no idea how long is the period between the hatching of the egg and the assumption of the adult form.

The egg hatches into a prenaupliosoma, which stage lasts only for eight hours or so. This changes to a naupliosoma which apparently makes its way to the surface and there changes to a phyllosoma in a few hours, according to Von Bonde and Marchand (1935), or in eight days according to Von Bonde (1936). Up to this time the little creature lives on the supply of yolk carried over from the egg but, after becoming a phyllosoma, it feeds on plankton. According to Gilchrist, the phyllosoma soon becomes negatively phototropic and seeks deeper water, but we are given no further information about the food and habits of the later stages.

After reaching a length of about an inch-and-a-half, the phyllosoma, in some unknown manner, changes to a puerulus that has more or less the form of the adult, but is transparent and only about an inch in length. Later, deposits of carbonate of lime appear in the cuticle and the little creature, as it moults and grows, assumes the colouring and appearance of the adult.

A study of the papers mentioned above reveals the fact that there are serious gaps in our knowledge of the metamorphosis of the crawfish and much more information is needed before we can attempt to rear them artificially on a large scale in order to replenish any beds that may be threatened with depletion.

The crawfish is a slow grower. A small male kept under observation by Von Bonde from January, 1933, to December, 1934 (when it died), increased in carapace-length from 0.95 inch to 1.15 inches, a growth of only a quarter of an inch in nearly two years. One specimen kept under artificial conditions cannot give any reliable indication, but it seems possible that a large male crawfish, with a carapace-length of six inches, may resemble a lobster of comparable size and be twenty or more years of age.

There is evidence that the crawfish beds in the vicinity of the Cape Peninsula are being depleted and further researches on this valuable crustacean are urgently needed.

A different species of crawfish is found in Natal waters at a depth of about 250 fathoms but this is not exploited at all at present.

OTHER SOURCES OF SUPPLY.

The papers by Marchand (1932, 1933) and Marchand and Taylor (1936) are valuable contributions to our knowledge of the sole fishery on the Agulhas bank. Marchand found evidence of "slow but nevertheless regular and alarming decline in productiveness" of the sole grounds, and he bases his assumption of over-fishing on the smaller catches per unit of effort—two baskets per 4-hour drag as against six to ten baskets in earlier years—and on the increased percentage of small soles ("slips") in the catch. Yet in those days, 1932, only 1,500,000 pounds of soles were landed annually, as against 5,000,000 pounds to-day. Unfortunately, the statistics of catches do not differentiate between the Agulhas sole (*Austroglossus pectoralis*) and the so-called super-sole (*Austroglossus microlepis*) which is an inferior fish and caught off the west coast.

Marchand showed that the Agulhas sole can be found spawning throughout the year, with a peak period during late spring and early summer, and that the fish do not attain sexual maturity until they reach a length of twelve inches. He recommended that the legal size limit should be raised from 9½" to 12" and that saving-gear (a panel with 3" mesh in the cod-end of the trawl) should be introduced, to enable small, immature fish to escape from the net. Regulations along these lines were promulgated and are still in force, although it seems that many "Slips" below the legal size limit still find their way on to the market.

Extensive taxonomic researches have been carried out on our marine fauna, particularly by K. H. Barnard and J. L. B. Smith. T. A. Stephenson and J. H. Day and their co-workers have done much valuable work on the ecology of the intertidal zone and this work is being continued by Day with special reference to our estuaries. Molteno has recently published a useful preliminary account of the tunas found in our waters. Essential information concerning the migrations, food habits and life cycles of our fishes of economic importance is almost completely lacking.

The molluscs around our coast are scarcely exploited at all. There are no records of the amount of oysters taken each year from the natural beds along our south coast but it is small and can be worth little more than £500 per annum. Even at this rate of exploitation and despite the fact that there is a close season of six months each year, the beds that are easily accessible have been seriously depleted because of the destructive, careless methods of collection.

Four years ago the Fisheries Development Corporation was fortunate in securing the services of H. G. Bright. Entirely at his own expense and without pay, he made a survey of the oyster beds along our coast. Then he proceeded to Europe and studied methods of oyster culture in France, Holland and Britain. At present he is in Canada, studying the methods used there. It was he who sent the three barrels of oysters from England to South Africa by air, as an experiment, but none survived the journey.

As a result of Bright's work, a company is now being floated to start oyster culture on a commercial scale in the Knysna lagoon and a Dutch expert is coming to this country in a few weeks' time to take charge of the work. It has been decided to use our own native oysters and not to import any from overseas because of the danger of bringing diseases and parasites with them. The chief weakness of this venture is our lack of knowledge of the South African species—we are not sure yet of its name and we do not even know whether it retains its eggs inside the body until they hatch or whether it ejects them into the sea.

The mollusc known as perlemoen in the country and as the abalone in the United States (*Haliotis midae*) is found along our coast but it is not exploited, although it is greatly prized in America and is of the highest-priced of all canned products. Black mussels (*Mytilus meridionalis*) and white mussels (*Donax serra*) are abundant but they also are not used as food to any extent.

The entry of Japan into the war in 1941 and the consequent cessation of supplies of agar-agar, a commodity of which she had held a world monopoly, caused the rest of the world to take stock and consider the possibilities of alternative sources of supply of this unique and indispensable material. For many purposes, but particularly in bacteriological work, it cannot be replaced by any other substance.

Guided by the investigations of Fox and Stephens (1943) and Isaac (1937, 1938, 1942), a sweet-making firm in Cape Town took up the manufacture of agar from local seaweeds and their chemist, P. S. Malan, turned out the first samples early in 1942. Later a second firm also took up the manufacture of agar on a commercial scale and today more than enough is made for our own needs and some is exported. It is estimated that the value of the agar made annually in South Africa to-day is between £40,000 and £50,000. Judging from what is happening in other parts of the world, and particularly in Scotland, this should be but the beginning of an important industry. The Scottish Seaweed Research Association is to spend £100,000 in research during the next five years and it is hoped that a great industry, worth something like £15,000,000 per annum, will be built up on products from seaweeds harvested round the coast of Scotland.

Conclusion.

The fishing industry in South Africa is developing very rapidly to-day and the development that is going on is sound and healthy. We still have great fishing grounds that have been scarcely touched and there are no sure signs yet of any serious over-fishing. The limiting factor threatens to be lack of fresh water.

Our commercial fishing grounds are situated mainly along the west coast, where the rainfall is very low indeed and the land bordering the sea is desert or semi-desert. There is a big Government scheme in hand at present to supply fresh water from the Berg

River to Saldanha Bay, St. Helena Bay and the Berg River-mouth areas. Further north the problem is much more difficult. The possibilities of providing Lambert's Bay with fresh water from the Olifants River are being actively explored, but there seem to be no adequate sources of supply for Port Nolloth, Luderitz and Walvis Bay, and the lack of fresh water at these centres may be a serious hindrance to large-scale developments. It is possible that the installation of big, modern condensing plants may prove to be economical and help to solve the problem.

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HYDRO-ELECTRIC POWER POSSIBILITIES IN SOUTHERN AFRICA.

BY

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Presidential Address to Section "A" of the South African Association for the Advancement of Science.

Read June, 1948.

South Africa, in common with many other countries is realising the value of its natural resources and the need for their conservation and utilization to the best advantage. In a country so arid as ours water conservation and utilization are matters of the greatest national importance, and the spectacle of a river in flood raises the question whether and why the energy of the rushing waters cannot be harnessed and turned to the use of the nation. In this age of machines, when electric power, cheap and abundant, is so essential to keep the wheels of industry in motion, I wish to attempt not only to assess the power possibilities that appear to me to exist in this country but also to explain why so little has as yet been done. It will be seen that in the Union of South Africa the possibilities are not great, and I have therefore also considered the rivers near our northern borders, namely, the Cunene, the Okavango and the Zambesi.

The area embraced by this survey is an immense one over which the rainfall varies from almost nothing on the west coast to 50 inches on the Zambesi-Congo watershed, with here and there much higher falls on high mountains. The rainfall is generally very strongly seasonal in character. In the summer rainfall areas of the Union something like 75 percent of the precipitation occurs from November to April, whilst a similar percentage occurs from May to September in the winter rainfall area.

This marked seasonal distribution of the rainfall has brought about an even more pronounced seasonal distribution in the run-off so that, for instance, in the Orange River eighty-two percent of the run-off occurs in the six months from November to April. Even in permanently flowing rivers like the Komati and the Blyde three-quarters of the flow occurs in six months of the year.

In order to test the power possibilities I have selected two rivers for detailed analysis, namely the Komati, because it is probably our most reliable river, and the Orange because that is our most important river in point of size and as regards total run-off. Careful analysis of the flow of the Komati indicates that if we had to install a power station on it without storage this might have a capacity

of 1900 kw from which, with pondage, we could expect to produce 10.8 million units of electricity per annum if sufficient water were available all the time. Actually there would not be enough water all the time and the position would be roughly as follows :—

With a maximum possible output of 10.8 million units the actual average annual output would be 2.2 million units short, whilst in a bad season like 1926-27 the deficiency would be 4.9 million units.

To maintain a steady supply of current, equivalent to the rated output of the station (1900 kw), it would therefore be necessary to have an auxilliary thermal station which on an average would have to produce 2.2 million units per annum. But in a bad season such as 1926-27 it would have to produce 4.9 million units. As, however, the flow may for part of the year drop to practically nil—a flow as low as 20 cusecs has actually been recorded—it would be necessary to have the auxiliary station as big as the hydro station itself.

This would mean that there would be two complete stations, one hydro and one thermal, each with rated capacity of 1900 kw. but that on an average 8.6 million units would be produced by the water and 2.2 by the thermal station.

There is no suitable natural fall in the Komati River except rather low down at the Tonga Falls, near Komatipoort, and the above analysis is based on the construction of a weir providing 50 feet of effective fall. A weir higher than that would be rather costly. The height of the weir does not, however, affect the water supply position ; the percentage deficiences remain precisely the same.

It is beyond the scope of this address to go into the economics which would determine whether such a course would be sound, but it appears extremely doubtful whether the capitalized cost of the coal which would be saved would be as much as the extra capital cost which would be involved in having a duplicated power station.

This is the picture without storage. Would the provision of storage alter the position radically? By analysis of the mass inflow diagram it is found that a station as described above would be able to operate continuously, without interruptions due to a failure of the water supply. We would, however, have to pay for the storage dam instead of for the auxiliary thermal station. But further analysis reveals that the storage dam would cost ten times as much as the auxiliary thermal station plus the capitalized cost of fuel required to drive it. Even if we increase the head to 100 or 150 feet the storage dam will still cost so much that from the economic point of view it would have to be ruled out.

The Orange River has been similiarly analysed and reveals an even more unsatisfactory state of affairs owing to the fact that that the low flow is at times practically nil. The Orange does, however, possess the Augrabies Falls and I have assumed that

450 feet of head could be used in a power station. If we build a station at the Falls based on a flow of 5,000 cusecs but, by providing pondage, instal plant capable of using a maximum flow of 7.500 cusecs, we have the following position :—

With a maximum possible output of 1,220 million units the actual average annual output over a long period would be only 743 million units, leaving an annual deficiency of 477 million units. In a bad season such as 1932-33 the actual output would be only 282 million units with a deficiency of 938 million units. But during a bad season the river flow drops to nil for part of the time so that if auxiliary thermal plant had to be installed it would have to be of the same capacity as the hydro unit.

With storage the position would be very substantially improved. By analysis of the mass inflow diagram it was found that a continuous draught of 5,000 cusecs could be maintained from a storage dam with a capacity equal to the mean annual run-off. To achieve this, storage of 6,000,000 acre-feet would be required. Such a structure on the Orange River is very unlikely to cost less than £6,000,000. To use a continuous flow of 5,000 cusecs a 215,000 kw. station would be required. A thermal station of this size might cost in the neighbourhood of £6,000,000 and would require approximately 1 million tons of coal per annum costing—at the Falls—about £1,000,000. But then if we had to build a thermal station we should do so at the Falls and coal would therefore not cost nearly so much. At the big power stations near Witbank and Vereeniging coal costs less than 5 shillings per ton.

Many examples similar to the Komati and Orange Rivers could be quoted. In each case the irregularity of the flow of the river would render power development unattractive without storage, even in localities where relatively high heads could be employed. If storage dams are added the physical conditions can be very materially improved but if the power plant has to bear the entire cost of storage it still remains doubtful whether anywhere in South Africa current could be produced on a substantial scale at a price to compete with coal.

Only by building multiple-purpose storage dams and by charging little or nothing of the cost of the dam to the power plant can there be any hope of producing electricity from water power on a substantial scale at a price equal to that from thermal stations.

We have at present only one locality in South Africa where an existing storage dam built for other purposes can possibly be used to produce electricity. That is on the Vaal River where a large storage dam constructed 25 miles east of Vereeniging supplies water to the industrial and urban area of Vereeniging, the Witwatersrand and Pretoria and to the large irrigation scheme 360 miles downstream in the Hartz River Valley north of Warrenton. The present capacity of this dam is 872,000 acre-feet, equal to about 40 percent of the mean annual run-off of the Vaal River. To supply water to the irrigation scheme and to various consumers

along the course of the river—which will soon include the Odendaalsrus gold mining area—a fairly large and comparatively steady flow is released from the dam so that the Vaal River to Christiana is now practically a perennial stream. In the 360 miles from Vaaldam, the storage reservoir, to the Vaal-Hartz diversion weir the river falls 850 feet. From the power point of view the most favourable stretch of river is between Parys and De Wet's Drift where the fall is 360 feet in only 60 miles. By building a weir, or weirs, and canals we might at the very most have available some 250 feet of effective head. We may assume that the flow of the river will never be less than 500 cusecs and that all or most of this can be passed through the power plant. In this way up to 70 million units of electricity could be generated from a station rated at about 8,000 kw.

This project has a good deal in its favour mainly because there is a possibility that any electricity produced by hydro stations could be fed into grids which are likely soon to be in existence along the Vaal River in this vicinity. On the other hand the cost of the necessary weirs and canals will be very high indeed so that electricity produced by water power is certain to be far more costly than that produced at the thermal stations near Vereeniging where coal costs under 5/- per ton, and where current is produced at a cost of one-sixth to one-ninth of a penny.

There are other localities in South Africa where no schemes have as yet been built but where investigations so far carried out indicate some possibility of operating power stations in conjunction with other uses. In this connection I wish to refer particularly to a project to divert the Orange River into the valley of the Great Fish River which flows past Cradock and discharges into the sea a few miles east of Port Alfred.

The project is an ambitious one and by far the biggest irrigation scheme which has so far been considered. Briefly there are two considerations which render the plan attractive. Firstly, there is singularly little arable soil in the valley of the Orange River so that there is little prospect of our being able to use the water of this river within its own watershed at anything like a reasonable cost. Secondly, a great deal of existing development in the Great Fish River and Sundays River valleys is threatened with extinction because the storage dams constructed there are silting up at an alarming rate. Bringing water from the Orange River will not only save all the development that has taken place but it will enable tremendous further expansion to take place, both in agriculture and in industry.

The plan is to drive a 50 mile tunnel through the Suurberg, which forms the watershed between the Orange and the Fish west of Steynsburg. Water from the tunnel would flow into the existing Grass Ridge dam, which can be made into a very large reservoir at moderate cost, and then down the Fish River. Between Grass Ridge and Cradock the river falls 650 feet and by a suitably constructed canal 500 feet of this could be made available for power

generation at Cradock. A steady flow of 500 cusecs or even somewhat more could be reckoned on and with suitable pondage some 150-200 million units of electricity could be generated per annum. Further down the river, at Cookhouse the plan is to divert water into the Sundays River valley. This involves only a very short tunnel and from the outfall of the tunnel to Lake Mentz a similar amount of current could be generated.

If the power units were not called upon to bear any portion of the cost of the tunnel or large storage dams, that is Grass Ridge and Lake Mentz, and bearing in mind that coal would cost 15/- per ton at Cradock there is a very strong likelihood that hydro stations would be able to provide current more cheaply than thermal stations. If the Orange-Fish tunnel scheme materializes and power can be produced as a by-product the matter becomes one of considerable importance, and the plan certainly deserves looking into carefully. At the present moment this project is the most attractive multiple purpose water utilization scheme which is under investigation.

One other project merits special mention and that is to build a storage dam on the Riviersonderend, near Villiersdorp, and to deliver the water through a short tunnel into the Bot River lying 800 feet lower where power could be developed. This project has much in its favour ; an excellent site, clear water, a dearth of irrigable soil, a high head, expensive coal and close proximity to a highly developed area with a big demand for power.

So far the generation of electrical power by means of water has been dealt with as if there were no conflicting interests to oppose or prevent such use. The Union of South Africa is, however, so extremely poorly supplied with water that I cannot imagine that in any locality, under any circumstances, would the use of water to produce power to the detriment of primary users and irrigators be tolerated.

In the development of our industries, our town water supplies and our irrigated lands, water will in many cases be the limiting factor. We simply cannot afford to use this water for power generation and thereby curtail or hamper that other development. After all, power can be produced in other ways, and generally more cheaply, but water is strictly limited by the scanty run-off obtained from our erratic and uncertain rainfall. If this viewpoint is accepted—and can anyone seriously contest it? then there can be but few places where power could be developed without some detriment to other more important interests. Power development at the Aughrabies Falls would, for instance, have to be ruled out entirely for the simple reason that below the falls there is not the remotest chance that large-scale development, requiring a great deal of water will ever take place. The ideal would be to use all the water of the Orange River before it reaches the falls, either for irrigation or for industrial purposes. If we generated power higher up the river it would be less attractive through not having the natural

fall and we would moreover be getting nearer to the sources of coal where cheap thermally produced power could be made available.

All investigators who have concerned themselves with the question of our water resources have pointed out how meagre these are and how essential it is to conserve and use them to the best advantage. We are today on the crest of a wave of prosperity coupled with a phase of generally good rainfall over South Africa as a whole and we are apt to think in terms of a vastly increased population sometime in the rosy future. It cannot be too strongly stressed, however, that in many localities the quantity of water available will be the final limiting factor in population growth and of course in production. Many rural areas are already fully populated—and in some cases even over-populated—and further increases founded on agricultural output cannot be expected. In many districts serious deterioration of land has been due to over-population and the resultant urge to take more and more from the soil.

If the populations are to increase in these areas it will have to be mainly on the basis of industries and not on farming, even allowing for very much improved agricultural methods. These industries will, however, require assured water supplies. Every drop of water will, therefore, have to be put to its best use, be that for agriculture or for industry. Power development simply cannot be allowed to compete with these two needs. The lack of water facilities or the need to reserve the water for other purposes need not worry us, however, because South Africa is very fortunate indeed in having immense coal resources.

This scarcity of water leads one to the inevitable conclusion that only where power can be generated in such a manner that no injury is done to agricultural or industrial interests can its use for that purpose be permitted. Even in a locality such as the Fish River where I have indicated fairly favourable conditions for water power generation, there may be times when the two interests will clash. For instance after heavy rain irrigation may not be necessary yet water may have to be released from storage for power generation.

Or in a season of bad drought the mode of distribution for irrigation may be unfavourable for power purposes. The latter needs a steady stream, hour by hour and day by day, whilst irrigation is more seasonal in character and may moreover be carried out intermittently. Ample storage may to some extent minimize these difficulties but storage costs money and storage practically everywhere in South Africa is a rapidly wasting asset due to silting.

The normal function of a river is to carry water to the sea. In doing so it also carries along the products of decomposition or of disintegration of the earth's crust. Where man has disturbed the harmony of nature as we have, to an alarming extent, done in South Africa, the rivers are heavily laden with these products. We are at the moment beginning—only just beginning—to wake up to the dangers, but until we have stopped talking about the problem

and have achieved something worth while our soil will continue to be carried to the sea and our storage dams will continue to silt up, despite frequent enlarging, some day to stand there as monuments to the folly of this generation. Until we can bring the rate of soil erosion down to a figure more comparable with that which nature has ordained it would be extremely unwise to snatch a fleeting dividend from dams constructed in our more silty rivers, particularly in the lower rainfall areas.

In the Fish and Sundays River Valleys siltation is robbing us annually of 7,400 acre-feet of storage on an original capacity of 288,200 acre-feet, and of a monetary value of £46,000 on an original cost of £1,646,000. In only 25 years of use the value of these dams has been reduced by two-thirds. We can go on enlarging the dams but in only a few generations time they will present such big evaporating surface areas to the scorching sun that they will be useless for storing water. The tragedy of this is that there are so few good sites in South Africa and when dams like Lake Mentz, Vaaldam, Hartebeestpoort and others are silted up there are no other sites of comparable merit on which to build. We should therefore jealously preserve our good storage sites for the vital purpose of supplying water to the great industrial and agricultural centres of development.

A few examples will serve to being out the paucity of our water resources compared with those of other countries.

If the entire run-off of South Africa could be impounded and released as a steady flow throughout the year it would amount to one-fifth of the mean flow over the Niagara Falls. In 1927 the Niagara power plants, although not fully developed, generated almost as much power as the Union does today.

Tennessee Valley in the United States has often been quoted as an example of the high standard of development achieved by a system of multiple-purpose dams. No example could possibly be selected of an area more dissimilar to South Africa. The average annual rainfall there is 52 inches, rising to 80 inches in parts; the run-off of the Tennessee River alone is half as much again as that for the whole Union. The average size of farms is 37 morgen; in the Free State, a territory about the same size as the Tennessee Valley, the average size of a farm is 600 morgen; there the population density is 100 per square mile; in the Free State it is four Europeans and 14 Natives. The mean annual run-off of the Tennessee Valley is 1,200 acre-feet per square mile; that of the Vaal River Valley is only 60 acre-feet.

In Germany with its network of permanent rivers, water power has been developed to a high degree. But the rivers of Germany produce far more run-off than anything we have in South Africa. Over a very great part of Germany the annual run-off exceeds 300 acre-feet per square mile, rising to over 3,000 acre-feet.

South Africa lags well behind other countries in the matter of supplying electricity on a nation-wide scale from central power

stations. Although not always due to sparseness of population this is generally the main reason. Cheap power at the power station will not overcome this difficulty, because even if the electricity were to be supplied free at the power station the high cost of transmission would still render it difficult to distribute it far and wide to villages and farms.

Our thermal stations produce very cheap power indeed. In 1945 the Klip Power Station near Vereeniging sold current at just slightly over one-tenth of a penny, comparing very favourably with the United States Bonneville tariff for firm power of 0.08d. per unit before the war. When it is remembered that our plant has to be imported the achievement is very gratifying indeed. The tariff for power sold by the Tennessee Valley Authority is two to three times as high as that for our three cheapest stations. Nowhere in South Africa is there any hope of producing power so cheaply in hydro stations. Small hydro power plants like those at Sabie, Umtata, Ceres and Barberton do, however, serve a useful purpose in making use of small permanent supplies of water, especially when the demand is too small to warrant the installation of steam plant and generators would have to be run by means of imported oil fuel.

Disappointing as it may be we must conclude that the generation of hydro-electric power on any substantial scale in South Africa is practically ruled out. Only in a very few favourable localities is such generation likely to be either physically or economically practicable. This is due mainly to the following considerations :—

1. The flow of South African rivers is too erratic and too uncertain.
2. Stabilization of the flow by means of storage dams will be very costly.
3. Water is so scarce that what is available must be reserved for domestic use and for agriculture and industry.
4. We have large reserves of coal and power can be cheaply produced in thermal stations.

When we turn our attention to the rivers of the northern territories the picture becomes very much brighter from the point of water supply. The Zambezi River and its tributaries, and the Cunene carry immense volumes of water. In both the Zambesi and the Cunene there are high water-falls where, at first sight, it would appear that conditions are favourable for the generation of hydro-electric power. The Victoria Falls are 380 feet high but allowing for the great height to which flood water rises in the gorge below the falls it would not be possible to use more than 320 feet of this. The mean flow of the Zambesi has been estimated at 38,000 cusecs but at times it drops to a figure which must be well below 10,000 cusecs. Using a head of 320 feet. power plant of 20,000 kw. could be installed for each 1000 cusecs diverted through the turbines. If the beauty of the Falls are to be maintained at

all times it follows that the water available for power generation would occasionally be reduced to a very small figure. This position could be very materially improved by the provision of storage, so that a constant flow of some thousands of cusecs would be available for the power plant, and yet leave available enough water for the maintenance of the natural beauty of the Falls. The provision of storage would however be attended with considerable difficulties. For the first 35 miles above the Falls to Katombora the river rises 127 feet—a gradient which is too steep to permit of economical storage. From Katombora upstream the gradient of the Zambesi becomes much smaller and economical storage becomes feasible. But the infall of the Chobe River (or Kwando) is just above Katombora and its gradient is so small that water would dam up for a great distance and a very large extent of the Caprivi Strip would thus become inundated. Only if the economic benefits of the scheme were sufficiently attractive would the inundation of so large a tract of land be warranted. Possibly a storage site higher up the Zambezi, above Katimo Molilo, could be found whereby the inundation of so much land could be avoided. The idea of storage above the Victoria Falls has much in its favour; it would ensure a constant flow of water for power generation and it would enable a more uniform flow of water to be maintained over the Falls. At present during the flood season so much water tumbles over them that they are to a large extent obscured by spray. With adequate storage and after allowing for the Falls, a steady flow of at least 25,000 cusecs could be made available for power generation. This would be enough to maintain a station with a capacity of half a million kilowatts generating in the course of each year some 3,000 million units of electricity. If more power were required this could be generated at the storage unit and at one or two of the more favourable rapids from Katombora to the Falls.

At the present time I can see no means of usefully employing this amount of electricity. A small quantity, not exceeding 30 million units, might be used to pump water for irrigation, and a small amount might be used for the secondary industries depending on agricultural produce, for instance sugar mills, saw mills and oil extracting plants, but this would be altogether insufficient to justify the establishment of a very large power station. For that matter all the power required for these purposes could be generated without storage at Katombora by means of a low weir and using only a fraction of the flow of the Zambesi. With a head of only 20 feet, and diverting only 4000 cusecs, 30 million units could be generated. Alternatively, of course, 30 million units could be generated at the Falls by using only 250 cusecs, but the current would have to be conveyed an additional distance of 36 miles to Katombora, because most of the land which might be irrigated lies above that point. The latter course would, however, almost certainly be the cheaper of the two.

The Chobe River, which in Angola is named the Kwando and inbetween the Linyanti, joins the Zambesi at Kazungula 44

miles above the Victoria Falls. Its mean annual flow I have estimated at 4 million acre-feet. Of this quite considerable volume of water, twice as much as that of the Vaal River at Vaaldam, very little reaches the Zambesi, the bulk of it being dissipated in swamps mainly in the Caprivi Strip. The gradient of this river is very small indeed and power generation is most unattractive especially in view of the fact that the Zambesi, not far away, offers much better scope. With power for pumping, derived from the Zambesi and also from the Okovango, the water of this river could be better employed for irrigating an enormous tract of land at present almost totally unproductive.

Further to the west from the Kwando is the Okovango River, surely one of the most interesting rivers in Southern Africa. There is a good deal of evidence supporting the view that the Okovango was not very long ago a normal tributary of the Zambesi. Today it contributes only an insignificant amount of water to the Zambesi, and that at long intervals, when it rises to an exceptional height in the flood season. The whole of its flow is evaporated in its own swamp area and it can therefore be treated as an independent river. From the point of view of power development the Okovango suffers from a serious drawback, namely that its gradient is rather small and any power stations built on it would have very low heads except at one spot, the Popa Falls, where there is a natural fall of at least 12 feet. A few years ago I examined the evidence available regarding the flow of this river and I then came to the conclusion that the flow of the Okovango was probably about 12 million acre-feet per annum or expressed as a mean flow 16,500 cusecs. Like that of the Zambesi the flow of this river is seasonal in character and the low flow falls well below the mean. We may, however, assume that the flow would seldom be less than 5,000 cusecs. If we had available 20 feet of fall, which could be obtained at the Popa Falls by means of a suitable weir, we should be able to generate about 50 million units of electricity in a year. The Okovango River is very sparsely populated and at present there is no use whatever for electricity. If we could find a profitable use for the power then an hydro-electric station might assume quite a promising aspect. It is submitted that all the power capable of being generated could be used to pump Okovango water onto the arid lands along the river thereby converting them into productive fields capable of feeding a very large population. At present the entire flow of the Okovango is being uselessly dissipated in thousands of square miles of swamps.

One of the greatest needs of Southern Africa is to increase its agricultural production without at the same time demanding more from soil which has already been grievously over-taxed. I am convinced that the immense tract of land, bounded on the east by the Zambesi and on the west by the Okovango River, can play a vital part in meeting this need. The rainfall is, however, inadequate to produce anything except occasional meagre crops from soils which rapidly become exhausted unless properly treated. By

irrigating the land the whole picture can be changed and the arid lands can be converted into a veritable granary for Southern Africa. Irrigating by gravity will not be a straightforward problem but some of the major difficulties can be overcome by pumping. Power from the Zambesi and from the Okovango, linked across the Okovango Delta down to Lake Ngami, could be harnessed to lift water from the shallow rivers to the low-lying lands.

The last of the great rivers in which we are interested is the Cunene. Its catchment area is almost entirely in Angola; in its lower reach it forms the boundary between Angola and South West Africa. The total annual flow of this river is probably something between that of the Kwando and of the Okovango, say, 6 to 8 million acre-feet per annum. Without storage the total flow is, however, not of great significance because the seasonal fluctuation is rather great and development based on the minimum natural flow would be very limited. The special significance of this river is that, in sharp contrast to the Okovango River, it has a very large fall. In the 24 miles just upstream of the Rua Cana Falls the river drops some 500 feet ending in an additional drop of over 400 feet at the actual falls. The early spring flow of the Cunene drops rather seriously, estimated by Kanthack to be about 500 cusecs. With pondage this flow would be enough to operate an 18,000 kw. station using 380 feet of the vertical drop at Rua Cana. From such a station an annual output of 117 million units of electricity could be obtained. A station using 1000 cusecs of flow would be capable of generating nearly double this amount because that flow would be available for some ten months of the year. Partial storage would ensure a steady flow of 1000 cusecs, and if use could be found for the power more could be generated in the section of the rapids above the Falls. Our neighbours in Angola are also interested in the Cunene and any exploitation of its resources would naturally have to be done on a basis mutually agreed upon. At the moment the barrier to develop is the apparent lack of any use for power. As in the case of the Okovango some of this could be used for pumping for irrigation, but this use would not be enough to absorb more than a fraction of the power which could be produced. The region lying to the south and west of the Rua Cana Falls holds some promise of yielding minerals and if payable bodies of ore are found there it might open up the possibilities of using power from the Cunene.

Let us return for a moment to the Zambesi River. So far I have dealt with possibilities at, or above, the Victoria Falls.

Some 300 miles below the Falls there is a gorge known as the Kariba Gorge. It is roughly 80 miles south-east of Lusaka and 175 miles north-west of Salisbury. A plan to construct an immense storage dam in this gorge is at present being investigated by the Southern Rhodesian Government. The site for the projected dam is upstream of the Kafue River and as the area between this point and the Falls does not yield a high run-off the volume of water available would be only slightly more than that which passes

the Falls. A mean flow of 38,000 cusecs passing the Falls would therefore yield with accretions say, 30 million acre-feet per annum. With storage this would yield a mean annual supply of about 25 million acre-feet equivalent to a steady flow of 34,500 cusecs. The storage dam to control so much water would have to be fairly high; also head would be required for power generation. If 250 feet could be obtained for this purpose a station of roughly, 700,000 kilowatts could be built, supplying an annual output of 4,700 million units of electricity.

This analysis has revealed that in the Union of South Africa the possibilities of developing hydro-electric power are meagre in the extreme, but that on the Zambesi and Cunene Rivers there are possibilities on a scale commensurate with those in other well-favoured countries. The question at the moment is however what to do with the current because the territories adjacent to the rivers are sparsely populated and unless use can be found for the electricity it would be useless to build large dams and power stations with capital and man-power that could be put to such good use elsewhere.

There are abundant signs that the darkness over the continent of Africa is being slowly lifted. Europe has suffered grievous blows in two world wars following each other in quick succession and the future of that continent is today shrouded in a fog of uncertainty. Her technicians and industrialists are turning their eyes to the virgin lands and untapped resources of this sub-continent. Along the Cunene, and along the Zambezi there is work for willing brains and hands and we can only hope that detailed investigation and cost analysis will reveal that power can be produced so cheaply that these territories can enter the industrial field on a competitive basis.

Throughout this address I have frequently had to make use of such terms as cusecs and acre-feet, and kilowatts and kilowatt-hour units. To some of you these terms may be unfamiliar and their significance not readily appreciated. I shall therefore indicate very briefly what they mean in terms of actual production.

Cusec is merely an abbreviation for cubic foot per second. An acre-foot of water is that amount which will cover an acre one foot deep; to irrigate a morgen of land for a year requires from four to eight acre-feet, depending on the nature of the crop grown. In our cities it is enough to provide water for a year for two families, even including a small garden. If this volume of water falls through a height of one foot it can in so doing generate about three-quarters of a kilo-watt hour of electricity.

The unit of electricity is, to the layman, perhaps even more difficult to visualize than volumes of water. A kilowatt-hour is the amount of work done by a motor of one kilowatt strength working for an hour, it will keep a hot plate or radiator going for an hour. In terms of man-power a unit of electricity can do as much work as a man in two full working days, or in some classes

of work even as much as he can do in five days. In a small home in a city today the amount of electricity used to perform the many tasks, from cooking the dinner to sweeping the carpets or washing the clothes, is equivalent to the mechanical work which could be performed by two or three score labourers. And when we speak of so many millions of units of electricity being used during the course of a year, the equivalent in man-hours is almost staggering. Every pound of coal that can be converted into energy, and every quarter million gallons of water that falls one foot, represents as much work as a labourer can perform in two to three days. We use in South Africa some 10,000 million pounds of coal to generate electrical power and this alone represents the work of some 50 million human slaves. With these millions of slaves at our service what can we command them to do because much will depend on the answer to that question whether many sources of untapped power can be profitably exploited.

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SOME FACTORS CONTRIBUTING TO THE ADVANCES IN ORGANIC CHEMISTRY.

BY

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Presidential Address to Section B of the South African Association for the Advancement of Science.

Read July, 1948.

The field of organic chemistry is now so vast that it is necessary to limit the area which it is proposed to cover in this address. The number of organic compounds is increasing daily, as more natural products are isolated and their constitutions determined and new synthetic compounds are made in the laboratories. There is no need to enumerate all the diverse types of compounds which find application ranging from vitamins and hormones to paints and varnishes. Rather than deal with any particular group of compounds it is more interesting to study some of the factors which have made possible the stupendous advance in this branch of Science.

Organic chemistry is said to have started with the synthesis of urea from inorganic materials by Wöhler in 1832. The analysis of these compounds had already been placed on a firm basis by their combustion in oxygen over copper oxide by the technique worked out by Dumas. In fact in 1831 he wrote to Guy Lussac "I have no hesitation in stating, and I am sure you will agree with me that . . . the analysis of an organic substance is a more simple and certain operation than the analysis of one of mineral origin. Discrepancies in the published analyses can usually be traced to the presence of impurities in the substances themselves."

The purification processes of distillation both at atmospheric and reduced pressures as well as those of crystallisation and sublimation served the organic laboratories for over 80 years. Substances of higher molecular weight however failed to yield to purification by these methods and it became important to find new techniques before further advances could be made.

The manipulation of vacuum distillation has undergone almost revolutionary changes with the advent of high vacuum technique. The essential principle involved is that by decreasing the pressure the mean free path of a molecule is increased so that once a molecule leaves a hot surface it travels direct to a cooler surface, placed at not too great a distance away, and condenses. This molecular distillation proceeds only at the surface of the hot liquid so that the

greater the surface exposed the higher the rate of distillation and the less the decomposition hazards. The actual lowering of the distillation temperature is not the significant factor. Olive (1944), quoting Hickman, gives some very interesting figures for relative rates of distillation employing the ordinary laboratory process of vacuum distillation and using the higher vacuum techniques.

	Pressure	Temperature	Relative Decomposition Hazards Approximately
Ordinary Claisen Flask	10 mm.	270°	500,000
Molecular Pot Still	0·001 mm.	130°	1

It will be seen from the table that the relative decomposition hazards are so enormously decreased that it is possible to appreciate why molecular distillation of high molecular weight substances succeeds where ordinary distillation fails. It should be appreciated, however, that all volatile components of a mixture will distil and the product is enriched with the constituent evaporating more rapidly, but a complete separation is difficult. The complete fractionation as is found in the equilibrium column is not realised.

The method of chromatographic adsorption, discovered by the Russian botanist, M. Tswett has given to organic chemistry further possibilities of advance. He showed that by pouring a solution of chlorophyll through a column of calcium carbonate "like the light radiation in the spectrum, so is a mixture of pigments systematically separated by the calcium carbonate column into its constituents". Then by cutting up the column and extracting the separate sections, or eluting with more solvent so that the individual constituents were washed through successively and individually, the components could be obtained pure. This method was only slowly employed in the organic laboratories but to-day it is part of a technique which must be taken from the research laboratories into the undergraduate classes.

In the time available for this address it is necessary to leave the problem of purification with only the mention of these two techniques which have received considerable attention, for purification is the first essential step in organic chemistry. Consistency of a formula and physical properties are no criterion of purity when it is remembered that stilbestrol m.p. 140-142° was only recently separated by Walton and Brownlee into stilbestrol m.p. 171° and ψ° stibestrol m.p. 151°. To further complicate matters varying physical properties do not necessarily imply a mixture: Kofler and Hauschild found that oestrone can exist in no less than three polymorphic forms, melting at 254°, 255°, and 259° (corrected), whilst Schulze (1936) found that the triterpene onocerin had a melting point of 232° or 202° depending on whether it had been crystallised from acetic acid or benzene. When it is remembered that the triterpenes generally have similar, and frequently identical, molecular formulae the difficulties in this field can be appreciated.

ANALYSIS.

The next step in the study of the organic molecule is that of analysis. In the method devised by Dumas it was necessary to burn completely about one fifth of a gram of a substance. As the study of more natural products involved smaller and smaller quantities the necessity of devising analytical methods employing micro quantities became necessary. We are reminded of the classical research of Sir Jocelyn Thorpe on the synthesis of camphor where after a series of twelve steps he was only able to isolate a few crystals of the camphoric acid.

The vitamins and hormones exist in nature in extremely minute quantities and less than 0.2 grams of pregnandiol could be accumulated from 1000-2000 litres of urine, i.e. a percentage yield of one thousandth of one per cent. One kilogram of dried yeast contains 20 milligrams of riboflavin (Vitamin B2): one five hundredth of one per cent.

The study and perfection of micromanipulation for the analysis of carbon compounds carried out by F. Pregl at Innsbruck and later by his pupil Hans Lieb in Graz have probably contributed more to the advances in organic chemistry than any other simple technique. By modern micro methods it is possible to determine the percentage of carbon and hydrogen of an organic compound with only about two milligrams or less of material. This advance in its time was only made possible by the perfection by that master craftsman W. Kuhlmann who, working in Bunge's workshops, made in 1910 the first micro balance with an accuracy of about 0.001 mgm. on a weight of 20 grams.—a sensitivity of one in ten million.

These micro methods cannot be said to have replaced *in toto* the older micro methods for substances of high molecular weight which can be obtained in larger yield. Ordinary analyses are not sufficiently accurate to distinguish between homologues of molecular weight 350-450 where differences for alternative formulae are very small. This is shown clearly in the figures for Cholestrol, viz:—

Berthelot	$C_{26}H_{44}O$	C 83·80	H 11·91
Reintzer 1888	$C_{27}H_{46}O$	C 83·86	H 11·91

Exact determinations have been made using larger quantities of one gram and employing the technique elaborated in the investigation of the atomic weight of carbon. This is best illustrated by the determination of Dihydrocholesterol $C_{27}H_{48}O$, by Fieser and Jacobsen (1936), viz.:—

	Found %	Calculated %
Carbon	83·439	83·436
Hydrogen	12·433	12·447

PHYSICAL MEASUREMENTS.

Once a substance has been assigned the molecular formula the problem of the constitution of the molecule is tackled along the lines of degradation. This aspect will be discussed later, as the

problems of constitution cannot always be elucidated by organic reactions alone. The stepwise breaking up of the sterols and the bile acids resulted in the assigning of formulae so that by 1928 the whole problem seemed settled, and Wieland and Windaus were awarded the Nobel Prize in recognition of the work of their teams. The actual formulae were, however, incorrect as they were a result of a series of logical arguments based on one or two erroneous assumptions. The correction came from the field of physics.

X-ray examinations on ergosterol led Bernal (1932), in a paper on the Carbon Skeleton of the Sterols, to state that "X-Ray examination of the Sterols pointed clearly to the fact that the older accepted formulae for these compounds could not be made to fit into the crystallographic cells . . . The newer formulae of Rosenheim and King are not open to objection and . . . serve to explain most of the general properties of the crystals whose structures have been studied."

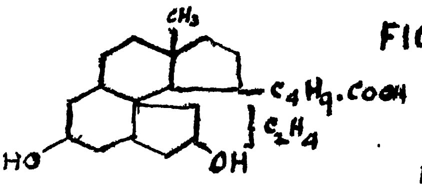
The actual dimensions are of interest in showing the degree of agreement between the observed and predicted figures for the different formulae.

ERGOSTEROL DIMENSIONS.

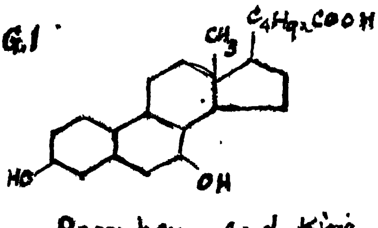
Wieland and Windaus Formula	8·5 x 7 x 18 Å
Rosenheim and King Formula.	7·5 x 4·5 x 20 Å
Found.	7·2 x 5 x 17-20Å

The actual modification of the formulation of the sterols to a phenanthrene structure can be illustrated by the structure of desoxycholic acid.

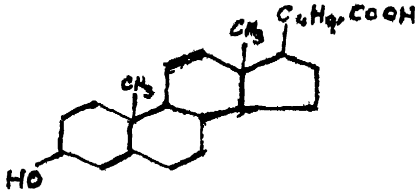
FIG. 1



Wieland 1948



Rosenheim and King
May 1932



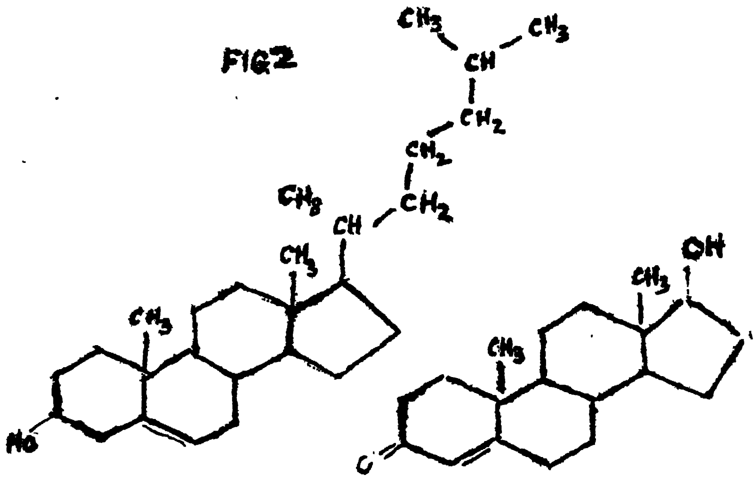
Accepted Formula.

This technique of single crystal X-ray analysis has led not only to the measurement of molecular dimensions but has also

contributed to configurational studies. Crowfoot (1944) employing this method was able to show that in one form of cholesteryl iodide "the side chain continues the general line of the sterol ring system" and is attached in the cis position to the neighbouring methyl group.

Molecular dimensions can also be obtained from the measurement of surface films, and using this technique Askew, Farmer and Kon in 1936 found for tigogenin, gitogenin and sarsasapogenin the limiting areas 38, 39·5, and 42 sq. Å per molecule, respectively. The formulae already proposed for the first two agreed entirely with the figures obtained. The disagreement between the found value of 42 Å and the theoretical figure led these workers to suggest a new structure in which the position of the hydroxyl group was changed in sarsasapogenin.

FIG 2



CHOLESTEROL TESTOSTERONE

It is possible to elaborate the importance of physical measurement by taking different physical properties in turn and showing how each could be employed to contribute to some aspect of structure, as for example, molecular rotation. This and other measurements are made as a matter of routine for the characterisation of substances, and when a large number of such measurements on similar compounds has been made it becomes possible to correlate with structure. The state of our knowledge or the difficulty of interpretation of results has limited the use of other instruments. To illustrate, a keto group conjugated with a double bond is reducible at the dropping mercury electrode, and this property has been used by Eisenbrand and Pitcher (1939) to determine hormones such as testosterone, which possesses this structure, and the possibilities in this field may develop. Additive properties, such as molecular refraction, are not sufficiently accurate for complex molecules of high molecular weight.

It must suffice, however, within the limits of this address, to mention briefly only one other important measurement easy to make and the apparatus for which is an integral part of the organic laboratory. The use of 'absorption spectra' is familiar to most, and similar light extinction curves are shown by compounds of similar structure. To-day, however, the technique has been so developed that particularly in the ultra violet (2000-4000 Å) region in which the outer electronic structure of the atoms comprising the molecule are operative, isolated multiple bonds can be picked out. The whole subject is well reviewed by Braude (1945) and two examples must suffice for illustration. The presence of two double bonds in ambrein $C_{30}H_{52}O$ but no absorption at 220 mμ necessitates that the two ethylenic linkages are not conjugated when comparison is made with the following:

	λ max.	log E max.
$C_4H_9\cdot CH{=}CH\cdot C_2H_5$	185 *mμ*	8000
$CH_2{=}CH\cdot CH_2\cdot CH_2\cdot CH{=}CH_2$	175 *mμ*	20000
$CH_2{=}CH\cdot CH{=}CH_2$	217 *mμ*	20900

On the other hand diketo-dihydro-lanosteryl acetate with absorption character λ max. *mμ* 275, log E max. 3195, led Ruzicka to assign a structure with the two keto groups conjugated with the double bond (-CO$\cdot$CH=CH$\cdot$CO-).

In the foregoing, an endeavour has been made to show the different techniques which have been employed not only to purify the material but to get some insight into the structure of the molecule. It cannot be emphasised too frequently that the quantities available are usually all too small to permit anything but the most planned experimentation. If any physical experiment can be performed which involves only measurement without destruction of the material it must be employed. Before any organic reactions are carried out it definitely pays to have made the necessary measurements, and, in fact, any laboratory not fitted with the modern equipment cannot hope to contribute to advance in the more important fields of organic chemistry. The apparatus which a few years ago was in the experimental stage in the physical laboratories is to-day a routine measuring instrument of the chemical laboratories.

DEGRADATION.

The impression may have been gained so far, that there is little chemistry in organic chemistry. Nothing can be lost by conveying this concept, for a greater appreciation is necessary of the contributions which can be made from allied fields of study to problems of the carbon compounds.

The degradations of the organic molecule have been carried out with almost devastating ruthlessness and it is surprising that the integral parts have survived the process. Such methods are still employed when a disruption of a too complicated molecule is required. I refer in particular to Vesterburg's dehydrogenation,

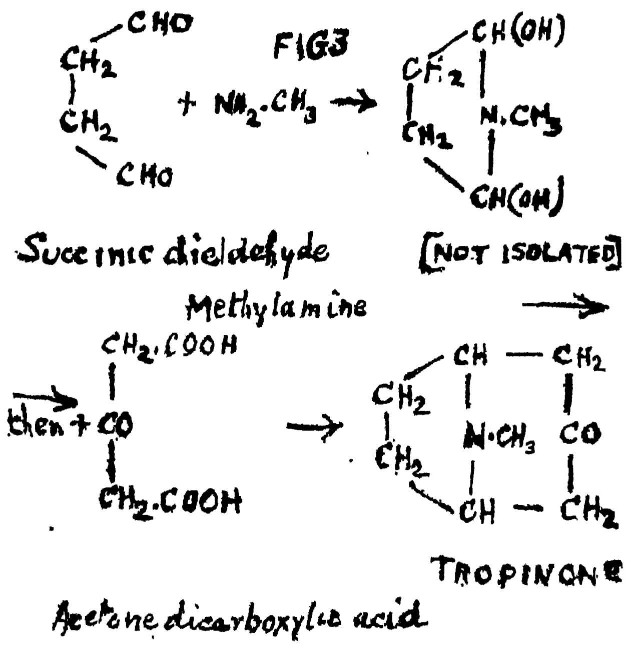
in which the substance is heated to 360° with selenium, when polycyclic compounds, such as the triterpenes and sterols, have been disrupted to simpler molecules. The yields in these cases are extremely small and starting with 50 grams, it is unusual to isolate more than a few milligrams of the pure products from a complex intractable material.

Modern methods using specific reagents have already made their effect felt in the precision of degradation. The classical researches of Wallach in the degradation of terpineol by oxidation with potassium permanganate, where he carried out experiments requiring hundreds of grams of starting substance giving complex mixtures, must be compared with the precision of that master of experimental chemistry, Ruzicka of Zurich. This latter worker frequently employs only milligrams of material for degradation experiments and yet separates his product into fractions of pure substances whose formulae he determines with accuracy. In no way should the classical degradation be scorned, but one should rather marvel at the skill in the separation of complex mixtures.

There is greater realisation to-day of the smoothness of biological processes and of the necessity for employing specific enzymes in the fission of organic molecules. Ordinary chemical reagents fail frequently to differentiate between similar molecular bindings. The two methyl-glucosides prepared by Fischer (1893) were readily split with hot dilute acids to regenerate ordinary glucose. By employing the selective action of enzymes Armstrong (1903) and Lowry (1904) were able to isolate two glucoses of different rotatory power: the alpha-methyl-glucoside being hydrolysed by maltase and the beta-form yielding to hydrolysis by emulsin. Another example taken from more modern work will perhaps emphasise the importance of enzymatic degradation. Numerous naturally occurring glycosides are compounds of the aglycone joined to several sugar molecules and hydrolysis by acids effects complete disruption into the parent molecule and a complex, frequently inseparable, mixture of sugars. Provided that the correct enzyme can be found it is possible to cause the fission of the sugar molecules stepwise and so render possible their isolation and characterisation as well as the order in which they are joined to the aglycone. The specific enzyme is frequently found in the plant in which the glycoside itself exists. The process resolves itself into first the extraction of the pure glycoside and then the isolation of the enzyme from another quantity of the same plant. An example is the isolation by Lamb and Smith (1936) of the only pure samples of digatalose. In two separate experiments they isolated from the seeds of *Strophanthus emeni* the amorphous glucosides and the enzyme. They then mixed these two substances when glucose was split off from the polyglycoside to give emicymarin which then was hydrolysed with acids to yield the aglycone and digatalose. The direct hydrolysis of the polyglycosides with acids resulted in sugar mixtures from which pure individuals could not be obtained.

SYNTHESIS.

Synthetic methods in organic chemistry have been so successful that the actual number of compounds made in the laboratories far outnumbers those isolated from nature. The yields in organic reactions have been, and in very many cases still are, very low. Nevertheless there is a decided tendency to-day to more precision in the organic laboratories, and here again this results from the employment not only of specific reagents but also of more controlled methods based on a deeper insight into the mechanism of the reactions determined by the physical chemist. It is interesting to draw attention here to Willstatter's masterly synthesis of tropinone involving over twenty reaction steps and to that precision experiment of Robinson who synthesised the same substance in high yield in one step at the ordinary temperature.



CONCLUSION.

It is hoped that, by glancing at some of the new procedures employed for the study of the organic molecule from the process of purification and analysis to the methods of degradation and synthesis, it will be realised that the contributions made by the other sciences have been enormous. Any one of the aspects referred to above could be selected and expended in a similar way to force the same conclusion. The ordinary cryoscopic and ebulloscopic methods of molecular weight determination, for example, fail

completely for high polymers whilst the centrifuge and the measurement of viscosity and double refraction of flow have succeeded in giving figures.

The organic chemist must appreciate these trends and realise the importance of discussion not only with those in the same field of study but also with his colleagues in other branches of Science. It is this that makes the Association meetings of such importance.

There is yet one other aspect of the broadening of the science of organic chemistry. The smallness of our research laboratories compared with those of Europe and America precludes our equipping our laboratories with all the instruments required, and in fact such lavish expenditure could not be justified. What is needed is a greater integration of our efforts so that the different centres can service one another for certain routine measurements. This does not imply the institution of controlled research but rather the inauguration of wider facilities.

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A PHYTO-GEOGRAPHICAL SKETCH OF MOZAMBIQUE.

BY

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Presidential Address to Section C of the South African Association for the Advancement of Science. Read June 29th, 1948.

Since the beginning of the 19th century, botanical expeditions have penetrated the African continent in all directions, continuously increasing the number of known species, advancing the study of Ecology and ultimately leading to the determination of phyto-geographical regions and sub-regions.

The study of African phyto-geography is based upon the works of eminent botanists, such as Grisebach, Chevalier, Engler, Bolus, Gossweiler, and others.

The oldest phyto-geographical conception of Africa, well founded when we consider the period of its origin, is that of the Kew botanists adopted in the *Flora of Tropical Africa*, 1868, which represents six regions: Upper Guinea, North Central, Nile Land, Lower Guinea, South Central and Mozambique.

In 1877 H. Grisebach divided Africa into four great regions: The North of Africa, the Sudan, the Kalahari and the Cape. The largest of these is the vegetative region of the Sudan, and in this the territory of Mozambique is included.

Later, in 1908, professor A. Engler introduced a phyto-geographical division of Africa which has attracted the largest following. According to Engler the African flora is characterized by four botanical regions: that of the Mediterranean, that of the North-African and Indian deserts, that of the forests and steppes and that of the South-Western Cape. The forest and steppe region agrees with that of the Sudan. In its turn this region is divided into four provinces: that of the Sudanese park and steppes, that of the elevated regions and steppes in North-Eastern Africa, that of forests in Western Africa or Guinea and that of the East and South-African steppes.

The province of forests and steppes is divided into several zones: Mozambique participates in the following: littoral zone, whose south end is the river Zambesi, zone of the high-lands of Niassa, zone of Zambesi and the zone of Gazaland.

In 1946 Dr. J. Hutchinson, presented a new phyto-geographical division of the African continent, which however, does not in its general lines, much depart from the divisions already mentioned.

According to Hutchinson four sections exist: viz. north-extra-tropical, tropical, sub-tropical South-African and a Cape section.

The tropical region is limited in the North by the Tropic of Cancer and in the South by the Rivers Cunene and Limpopo, and by the Lake Ngami.

Four regions form the tropical section : that of deserts and semi-deserts, that of savannahs or tableland, that of high mountains and that of tropical hygrophytic forest. The Territory of Mozambique forms part of the region of savannahs or tablelands and of the eastern part of the south-african sub-tropical section.

The flora of Mozambique contains different types of vegetation. In the classification of these types of vegetation we may follow any of the generally accepted systems ; as for example the systems of Tansley and Chipp or of Rübel and Brockmann-Jerosch. The first-mentioned of these systems is the simplest as it does not go into a minute description of the types of vegetation. It deals in generalities, as is done on this occasion, and we have to take into consideration the fact that the Mozambiquean Flora is not known sufficiently well to utilise a very detailed system of ecological classification. For this reason I shall follow the system laid down by Tansley and Chipp, suggesting nevertheless, a classification that conforms to the system set forth by Rübel and Brockmann-Jerosch. Taking the Tansley and Chipp classification as a basis, we see that the indigenous vegetation of tropical and sub-tropical Africa presents the following natural types and aspects and for the main deliminations the accompanying map should be consulted.

1. Hygrophyte Forest.

Closed forest (Tansley and Chipp) ; pluviilignosa (Rübel and Jerosch) : Covered with dense wood ; 3-5 strata of vegetation ; strong and numerous lianas ; a grass stratum that is either slightly dense, or thin or non-existent for lack of light.

a. Forest of Periodical Rains and Fogs.

Rain forest (Tansley and Chipp) ; pluviisilva and lauriisilva (Rübel and Brockmann-Jerosch) : Unbroken forest, dense, and growing in low altitudes—up to about 300 metres, the temperature is high and constant. The dry season is short or absent. The epiphytic flora is rich in ferns and orchids.

b. Forest Gallery.

Fringing forest (Tansley and Chipp) ; lauriisilva (Rüben and Brockmann-Jerosch) : Continuous and dense forest, circumscribed by the moist soil of the river banks and the water lines.

c. Mountain Forest.

Mountain Forest (Tansley and Chipp) ; lauriisilva (Rüben and Brockmann-Jerosch) : The forest is uninterrupted, high and dense, with 3 or 4 strata of vegetation, covering some of the most elevated mountains of tropical Africa ; it generally lies under the influence of constant clouds and fogs ; the temperature is moderate ; the apiphytic flora is very rich in lichens.

d. Mangrove.

Mangrove (Tansley and Chipp); lauriisilva and lauriifruticeta (Rüben and Brockmann-Jerosch): Tree formations or dense shrub that cover soils which are solely subject to the activity of salt water.

2. Sub-Hygrophyte Forest.

Transition from closed forest to parkland (Tansley and Chipp); lauriisilva (Rübel and Brockmann-Jerosch): The forest is unbroken and dense, and of hygrophytic appearance, with 3 or 4 strata of vegetation, localised in moist dales and in mountain ravines. The forest continues in some density, and is of an appearance similar to hygrophytes, having the appearance of islands of irregular outline surrounded by savannah or steppe.

3. Xerophyte Forest.

Parkland (Tansley and Chipp); hiemilignosa (Rübel and Brockmann-Jerosch): Forest of little density and sometimes scattered, with 3 or 4 strata of vegetation. Dominance of deciduous leaves in periods of drought (the caducity of the leaves is sometimes very irregular, but almost always takes place at the end of the dry season). Lianas are absent or rare. The grass stratum is uninterrupted.

a. Open Forest.

Open woodland (Tansley and Chipp); hiemisilva (Rübel and Brockmann-Jerosch): Trees scattered or in groups; dense grass stratum, with a dominance of gramineae.

b. Savannah Forest.

High grass and low tree savannah (Tansley and Chipp); hiemifruticeta (Rübel and Brockmann-Jerosch): Trees of little height, existing in groups or isolated, with short trunks, knotty, and generally of a dark colour; gramineae of 1.5-3.5 metres in height.

c. Orchard Formation.

Orchard country (Tansley and Chipp); hiemisilva (Rübel and Brockmann-Jerosch): Trees scattered in vast areas of grass vegetation; tops generally spheriform, offering conjointly the aspect of an orchard. Sometimes those trees are only palm-trees.

d. Thorny Forests.

Thorn country (Tansley and Chipp); hiemisilva and hiemifruticeta (Rübel and Brockmann-Jerosch): Generally trees of a poor bearing, or thorny shrubs dispersed or in groups. The dry season is lengthy and the temperature high.

4. Steppe.

Grassland (Tansley and Chipp); herbosa (Rübel and Brockmann-Jerosch): Grass or sub-shrubby vegetation, generally covering the soil entirely; absence of trees and shrubs, or at least very rare and of poor bearing.

a. Steppe of Low Altitude.

Transition from parkland to grassland (Tansley and Chipp): Areas of grass and sub-shrubby vegetation of low growth; trees

and shrubs, when to be found, are of dwarfish form, due to fire, soil and cattle.

b. Steppe of High Altitude.

Mountain grassland (Tansley and Chipp): Areas of grass or sub-shrubby vegetation of the high altitudes, encircling generally a hygrophyte forest of dales and ravines and a mountain forest, or extensive in the most elevated tablelands ; sometimes with small trees and dispersed shrubs.

5. AQUATIC VEGETATION.

Maritime, swamp and aquatic vegetation (Tansley and Chipp) ; aquiherbosa (Rübel and Brockmann-Jerosch): Floating grass subject to periodical inundations or dependent on the elevation of sheets of underground water.

a. Vegetation of Salty or Brackish Water.

Maritime vegetation (Tansley and Chipp) ; submersiherbosa (Rübel and Brockmann-Jerosch): Groups of grass that float on or are submersed under the sea or in lagoons with salty or brackish water.

b. Fresh Water Vegetation.

Swamp and aquatic vegetation (Tansley and Chipp) ; submersiherbosa (Rübel and Brockmann-Jerosch): Groups of grass floating, submersed or amphibious in rivers, fresh water, lagoons or in swamps.

c. Vegetation not subject to immersion, but rooted in moist soil.

Strand-vegetation (Tansley and Chipp) ; emersiherbosa (Rübel and Brockmann-Jerosch): Grass groups on the beaches, the river banks and the shores of lagoons with salt water, and also on the shores of lagoons with fresh water.

The classification by Rübel and Brockmann-Jerosch presents various divisions of these vegetative types, which I do not quote because of their minuteness. The same classification deals moreover with two types of vegetation that are not discriminated by Tansley and Chipp: that of the desert and that of the micro-organisms that live suspended in the air, in the water and in the soil (phytoplankton). I am not going to describe them here as they do not offer the necessary importance for this study.

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After this synopsis of the different aspects of the tropical vegetation of Africa, let us now examine in more detail the characters that are of greater interest to us.

THE HYGROPHYTE FOREST. This type of vegetation is represented in Mozambique by the forest gallery, mountain forest, mangrove and passages of forest that are very similar to those of periodical rains and fogs. But since the last are not typical "rain-forest" I prefer to include them in the group of sub-hygrophyte forest.

The wooden galleries are dominant groups of uninterrupted, ever-green trees that stand along the rivers in soil that is subject to the direct activity of water. They offer normally two aspects: that of plants whose roots penetrate into the water, and that of plants that merely use the moisture of the soil. Such groups have the shapes of tunnels or galleries, especially when they are narrow and of high carriage, and from that peculiarity they derived their name. Professor Chevalier defined the forest gallery as "the tentacles of the great equatorial forest", which find the moisture they need on the banks of the water ways.

Of the more interesting tree species of the gallery forest I quote the following: *Khaya senegalensis* and *Khayanyasica*, *Erythroploeum guinnense Adina microcephala*, *Cleistanthus holtzii*, *Treculia africana*, *Parkia filicoidea*, *Diospyros mespiliformis*, *Pseudocadia zambesiaca*, *Syzygium cordatum* and *S. guinnense*, *Pandanus livingstonianus*, *Barringtonia racemosa*, *Hibiscus tiliaceus*, etc. The last two species form large communities along the rivers of the South of Mozambique.

In spite of the constant and intensive felling of which they have been a target, there are still some gallery forests of great extent left which it would be useful to preserve, for example those on the banks of the rivers Lugenda, Licungo, Save, Limpopo, Maputo, etc.

The mangrove area consists of shrub or small ever-green trees with coriaceous leaves, and seldom of tall trees or low shrub. It exists merely on the banks of estuaries and of certain re-ingresses of the coast subject to the action of salt water.

The sandy and oozy soil is subject to the influence of the tide. For that reason the species that make up the mangrove are provided with roots of negative geotropism (pneumatophores) that allow them to breathe while the soil is covered with water. The mangrove plays a very important part in the fixation of soil and its destruction causes both structural and economic damage. The most common species are the following: *Avicennia marina*, *Rhizophora mucronata*, *Brughiera gymnorhiza*, *Languncularia racemosa*, *Sonneratia acida* and *Heriitira littoralis*. Among the most important mangroves of Mozambique are those along the rivers Zambesi and Bons Sinais, those along the Bay of Inhambane, and those on the Islands of Chiloane, Inhaca, Querimbas, etc.

In the zones of higher altitude—being 300 metres altitude in regions farthest from the equator, and 2000 metres altitude nearest the equator (the mountains of Cameroon, Kenya, Kilimanjaro, Ruwenzori, etc.)—there exists a dominant arboreal vegetation of hygrophyte appearance that is called "Mountain forest". This type of vegetation, besides being little represented, is little known in Mozambique. It exists, as far as I know, in the mountains of Gorongosa and Chimanemane, in altitudes above 2000 metres.

Among the species present the two coniferae *Widdringtonia whytei* (or "Cedar of Milange") and the *Podocarpus milangianus* are the most prominent.

SUB-HYGROPHYTE FOREST. We find the hygrophyte forest in Mozambique—besides the types I have already mentioned—in narrow and moist mountain valleys where it gives the impression of a gallery forest, when it does not assume the special character of a mountain forest. It reaches normally a height of 15-20 metres. In the mountains of Namuli, Chimanemane and Macequece the purest forms of this type are found.

But more frequent is that forest which displays a greater density than the normal xerophytic forest; it attains a greater height, has a compact shrub stratum, epiphytic plants in large numbers, specially ferns (*Platycerium*, *Adiantum*, *Asplenium*) and orchids (*Angraecum*), and in short it offers an aspect that truly resembles a hygrophyte forest. Such a forest—I call it "sub-hygrophyte"—corresponds to regions that are very moist and of uneven relief—as those of Amatongas, Tacuane, Inhaminga, Milange, of the low-lands south-east of the Namuli mountains, of Ile, and on a small scale, in the regions of Monapo, Imala, Pomene, Goba, etc.

Of the species that form part of this type of vegetation I wish to quote the following: *Chlorophora excelsa*—a tree that produces the finest wood to be found in the whole of Africa—*Chrysophyllum welwitshii, Bombax rhodognaphalon, Androstachys johnsonii, Phialodiseus zambeziicus, Piptadernia Buchananii, Vitex cienkowskii, Uapaca sps., etc.* These patches of vegetation demonstrate that there once existed an ancient and vast area of a hygrophyte and sub-hygrophyte forest appearance, but little by little it has perished, cut down by the natives for the cultivation of their fields and by colonists for the same purpose, for the exploration of wood and other reasons. There are, one may say, vegetative islands of hygrophyte appearance girdled by steppe, and scattered through the wide sea of a xerophyte forest. The cultivation of tea in some of these regions has essentially been responsible for the disappearance of much of this interesting and valuable type of forest.

XEROPHYTE FOREST. The largest part of Mozambique's wooded surface is occupied by xerophyte forest, and this in spite of the continuous cutting it has undergone and is still undergoing. In the same way the hygrophyte forest has gradually vanished by the action of man and physical agencies and is substituted by the xerophyte forest, which will in turn perish, and be replaced by grass and shrub formations. It is a process of the advance of the steppe—a phenomenon that in recent years has absorbed the attention of botanists: in a wider sense it is the progressive desiccation of Africa. The hygrophyte forest as well as the xerophyte forest will entirely pass away if timely and energetic measures for their preservation are not taken.

Frequently a xerophyte forest exhibits itself in large groupings, separated by the steppe, bearing thus up to a certain point, the semblance of a park; it is therefore also called "parkforest", or "parkland".

The presence of a xerophyte forest indicates a climate with a relatively high temperature, a low rainfall and of a lengthy dry season.

Side by side with the species with caducous leaves and dry fruits there grow also some species that are evergreen and produce fleshy fruits, but they exist in small quantity and, as a rule, they prefer moister and more sheltered places.

One of the characteristics of the xerophyte forest is the high number of species that contribute to its composition, species moreover that belong to many different genera and families. The dominance of certain genera in different areas leads us to the division of the xerophyte forest into the sub-types, previously mentioned, which may now be considered in more detail. Thus the savannah forest is formed by small trees, either isolated or in groups with tall gramineas, 1.5 to 3.5 metres high. Due to the dominance of grass plants, fire spreads rapidly in the savannah forest, and the few trees that exist there, suffer great damage ; they are retarded in their growth if they survive at all. Thus we have here a forest type, which because of its constant degeneracy, is on the road to extinction. An open forest is the most common type of the xerophyte forest. The dominance of certain genera causes in such a forest also various and well-defined aspects. The principal aspects or dominancies are those of *Brachystegiae*, of *Trichilia-Sclerocarya*, of *Combretacea-Strychnos*, of *Uapaca spp.* of *Copaifera mopane* and mato de dunas (wood on downs).

The most common aspect or dominance from the Rovuma River to the Limpopo River is that of Brachystegiae. There exist various species of this genus in Mozambique : *B. appendiculata*, *B. randii*, *B. hookii*, *B. edulis*, etc. Unfortunately this interesting aspect of the xerophyte forest is doomed to vanish and this within a few years sooner than any other aspect. The constant demolition that is done to it in order to make room for cultivation, rail-road lines and villages, and to extract tannin and fibre from its barks, hastens its annihilation.

And with the disappearance of the *Brachystegiae* there will disappear one of the greatest agricultural products of Mozambique—wax—for the flowers of these plants are most melliferous.

The southern limit of the *Brachystegiae* is the Limpopo River. The dominance of *Combretaceae-Strychnos* is also very common, in the northern regions as well as in the southern. Species of the genera *Combretum* and *Terminalia*, as also of the genus *Strychnos* (*S.spinosa*, *S.Gerrardii*, etc.) are the most prevalent.

The dominance of *Trichilia-Sclerocarya* is very usual in the region south of the Save River, but more towards the coast than towards the interior. *Trichilia emetica* and *Sclerocarya caffra* are the most sweeping species ; the natives are in favour of their propagation since they make use of their fruits.

The dominance of *Copaifera mopane* corresponds to west regions of low and median altitude and of very little rainfall. The

dominance of *Upaca spp.* appears above all in the tablelands of the interior, in heights of more than 500 m. ; the most common species is certainly *U.Kirkii.*

In the regions of the coastal dunes the open forest presents a special ecological type, distinguished by its great density, and above all by the uniform and small height, a feature that is caused by the constant activity of winds that blow from the sea. The species that compose the forest of the dunes are also to be found in the interior. Some of them such as *Dialium schlechteri* and *Afzedia quanzensis* which in the interior of the territory reached the height of trees, are dwarfed in the dunes to mere shrubs. The Casuarina, *C.equisetifolia* is one of the typical plants in dune forest.

The "orchard" formation is to be found more or less throughout the whole territory. Certain species such as *Combretum zeyheri, Strychnos spp., Bauhinia thonningii* and *Syzygium cordatum* frequently form part of this type of vegetation.

The thorn forest is to be found especially in the more arid regions of the south of Mozambique. Species of the genus *Acacia* are the most common and two of them—*A.mossambicensis* and *A. xanthophloea*—are well-known.

THE STEPPE. Looking at this type of vegetation we have to consider, as we have already seen, two aspects : the steppe of low altitude and the steppe of elevated altitude.

The first constitutes something like a transition form from a xerophyte forest to a steppe ; "Transition from Parkland to Grassland" to use the words of Tansley and Chipp.

Species of the genera *Panicum, Andropogon, Eragrostis, Themeda, Rhynchelytrum, Urochloa, Hyparrhenia, Setaria, Cyperus, Mariscus,* etc. form the large mass of the steppe of low altitude. Its economic importance is high, as this type of steppe produces good pasture, especially in areas of higher rainfall.

The steppe of elevated altitude, or mountain steppe lies in the more eminent tablelands, mainly in those on the mountains tops. It is also rich in good pastures.

AQUATIC VEGETATION. On the rivers of Mozambique that are of sluggish current and also on the shores of the fresh water lagoons it is usually a common experience to come upon certain aquatic plants, as for example *Ceratophylium demersum, Nymphaea spp, Pistia stratiotes,* etc. On the Incomati River an abundance of a floating plant, *Eichornia crassipes* is noteworthy. Its homeland is Brazil. Finally we have beach vegetation ; here we encounter, among others, common species which are well-known: *Canavalia obtusifolia, Ipomea pediscapra, Suriana maritima, Scaevola plumieri, Suaeda fructicosa, Arthrocnemum indicum,* etc. On the beaches of the south a coarse grass, *Halopyrum mucronatum* is dominant. It gives the sand a very strong fixation.

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After this short review of the diverse general types of Mozambique's vegetation, let me now say a few words about the orography

and the climate, so that, in the light of these two elements, we may may define the botanical regions of Mozambique.

Examining an orographical map, we discover that the territory of Mozambique rises slowly from the coast towards the interior, and that the first mountains only come in sight at an elevation of about 400 metres. Altitude of 2000 metres and over are to be found mainly north of Zambesi River : the Mountains of Namuli, Tacuane, Alto Nyassa, Angonia and Chissindo.

South of this river we have only the mountains of Chimanemane and Gorongos. The Lebombo Mountains, situated in the extreme south, possess a typical flora, due to the sub-tropical situation, and not to the altitude which does not exceed 600 metres.

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With regard to the climate we have to distinguish three zones ; that of the north, enclosed by the Rovuma River and the 16th parallel approximately, is subject to the influence of the monsoons ; that of the south, encompassed by the Save River and the southern frontier, is of anti-cyclonic character and of depressions of the median latitudes ; and that of the centre, or intermediate climate, that shares the conditions of the two others.

The climate of the north is visibly alike up to heights of about 1000 metres. The median annual temperature lies between 25° and 26° C. on the coast. The hottest month is December (27°5 C.) and the coolest is July (22°.5 C.). The hot, or the rainy season runs from October to April (North-eastern monsoon) and the fresh or dry season from May to September (South-western monsoon). The median annual rainfall is 1000 m/m, being in some places much higher, in others much lower. The rainfall is at its greatest in the beginning and at the end of the rainy season. The relative humidity is 72%. In the intermediate region the zones of the greatest rainfall of the whole territory exist between Beira and Quelimane, Ile, Namuli, Milange and Tacuane. The rainfall at the coast is 1.250 m/m in the region of Ile 1.880 m/m and in the mountains of Namuli, Milange and Tacuane it even exceeds 2000 m/m, permitting thus the cultivation of tea. The rain frequently amounts to 100 days per year.

The median annual temperature is 24° to 25° C.; the hottest month is January (27°.5 C.) and the coolest is July (20°.5 C.) ; Relative humidity is from 71 to 74%.

Part of the intermediate region, corresponding to the Zambesi valley, constitutes a sub-zone where the rainfall is smaller, decreasing to 700 m/m, when the rain frequency amounts to 52-55 days.

In the climatical zone of the south the median annual temperature is 22° to 23° C., with considerable daily changes. The relative median humidity is 68 to 72%. The median rainfall at the coast is between 750 and 1000 m/m, increasing from the south towards the north.

This zone is divided into two sub-zones: The Limpopo-Chengane-Incomati Zone has a median annual temperature of 23° to 24° C. The extremes are very remote; they lie between 0°.2 and 47°C. The relative median humidity is 72 to 74% and the rainfall is rather small, amounting in the area of the Pafuri to 318 m/m only; the Lebombo Mountain Zone possesses a regular climate and enjoys average temperatures and rainfall that are higher than in the interior.

. . . .

Relating the vegetation to the altitude and the climate we are able to outline the following botanical regions:

1. THE COASTAL OR MARITIME REGION.

This is formed by the entire coast, the coastal islands, the maritimo dunes and the estuaries of the rivers that are subject to salt water influence.

The rainfall amounts to 600—1.250 m/m. It experiences the perpetual influence of maritime agencies, as wind, humidity etc. and it exhibits beach vegetation, mangrove and dune brushwood. This region maintains its course in the South-African territory through the coastal part of the Eastern Coast Region (Pole Evans), and in the Tanganyika Territory through the Mangrove region (Engler) of the left bank of the Rovuma River.

2. NORTHERN REGION OF PLAINS AND HILLS.

This stretches between the rivers Rovuma and Limpopo and from the maritime dunes up to an altitude of 450 metres approximately, where the first mountains become manifest.

It follows the lower and median course of the rivers up to a great distance from the river mouth, and it sometimes spreads out to a large extent. The alluvial part of the Portuguese shore of the Lake Nyassa that has an altitude of 490 m. and the Chire valley forms part of this region.

The rainfall varies greatly—from 318 to 1.250 m/m—the maximum lying between Beira and Quelimane, and the minimum in the region of Chengane-Limpopo.

The steppe is of little altitude and alternates with forest. There exists xerophyte forest of all types, gallery forest and places of sub-hygrophyte forest. *Brachystegia* dominates huge areas; *Trichilia-Sclerocarya* prevails south of the Save River. *Adansonia digitata* exist on many points of the coast, along the banks of the rivers Zambesi, Chire, on the shore of the Lake Nyassa, etc. There are extensive areas of *Copaifera mopane* in the Tete district—the southern part of the Zambesi-basin—and in the region of Massangena-Parfuri-Limpopo; the latter one is interspersed with numerous sub-hygrophyte masses of *Androstachys johnsonii.*

This region links up with that of Mopane Bush (Pole Evans) in South Africa, with the "Trockenwald" (Engler) in the Tanganyika Territory and with the Mopane (Henkel) in Southern Rhodesia.

3. THE SOUTHERN REGION OF PLAINS AND HILLS.

It stretches from the Limpopo River up to the southern boundary and from the maritime dunes to the base of the Lebombo Mountains. Its rainfall lies between 750 and 1000 m/m at the coast.

Xerophyte forest here unfolds all its different features. Open forest is characterized by the non-existence of *Brachystegiae* whilst *Combretum-Strychnos* and *Trichilia-Sclerocarya* prevail largely. Thorn forest is frequent, mainly in the extreme south. Lagoon and swamp vegetation flourishes. Steppe of low altitude alternates with forest. *Andansonia digitata* does not exist, except in restricted places, as in Magude and Pafuri. *Copaifera mopane* is dominant in the northern section of the Lebombo Mountains. This region links with the regions of the Eastern Coast and the Mopane Bush (Pole Evans) of South Africa.

4. THE MOUNTAINOUS UPLAND REGION OF THE NORTH.

This extends from the northern and western frontiers up to a difference of altitude of nearly 450 m. Its southern limit is the Buzi River. It includes the uplands and mountains up to the point where forest appears. It is interrupted in the Tete district by the region of plains and hills in the north, along the Zambezi valley. Rainfall varies from 1000 m/m in the uplands to a little more than 2000 m/m in the mountains of Namuli, Milange and Tacaune. The steppe of low altitude changes with forest.

Xerophyte forest presents itself in all its various patterns ; it is particularly an open forest. Large areas are dominated by *Brachystegiae* and *Combretum-Strychnos*. Hygrophyte forest is found in the mountain ravines and on moister slopes.

Gallery Forests.

Sub-hygrophyte forest is rather frequent. Mountain forest exists in the mountains of Chimanemane and Gorongosa in which coniferae occur. Dominance of the *Copaifera mopane* is noted in that part of the Tete district that lies south of the Zambezi River. It corresponds in Southern Rhodesia with the regions of grassland, woodland, closed forest, open forest and Mopani (Henkel) and in the Tanganika Territory with the "Trockenwald" Region (Engler).

5. THE MOUNTAINOUS UPLAND REGION OF THE SOUTH.

It stretches along the Transvaal frontier and the Lebombo Mountain of Swaziland, its altitude does not exceed 600 m. and the rainfall lies between 800 and 1000 m/m.

Dominance of steppe of low height with scattered shrub is noted. Sub-hygrophyte forest inhabit the ravines and the humid slopes of the mountains. Open forest is rather scarce. The existence of certain typical genera of the Cape flora such as : *Gazania*, *Gerbera*, *Arctotis*, *Pelargonium*, etc. is also noted, and is comparable with the low Veld (Pole Evans) of South Africa.

6. REGION OF HIGH ALTITUDE STEPPE.

It includes the areas lying on mountain tops, covered with gramineas and other grass plants and interspersed with small trees

and shrubs. This corresponds to the mountain grassland (Henkel) in Southern Rhodesia.

7. SUB-ALPINE REGION.

It is made up by the arid mountain rock peaks, reaching a height over 2000 m.

Its vegetation consists almost exclusively of saxatile plants.

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In this way the phyto-geography of Mozambique may be sketched taking altitude, and climate as a basis.

Each region mentioned can be sub-divided. However, the study of Mozambique's flora is not sufficiently advanced to allow it to be done with the necessary precision.

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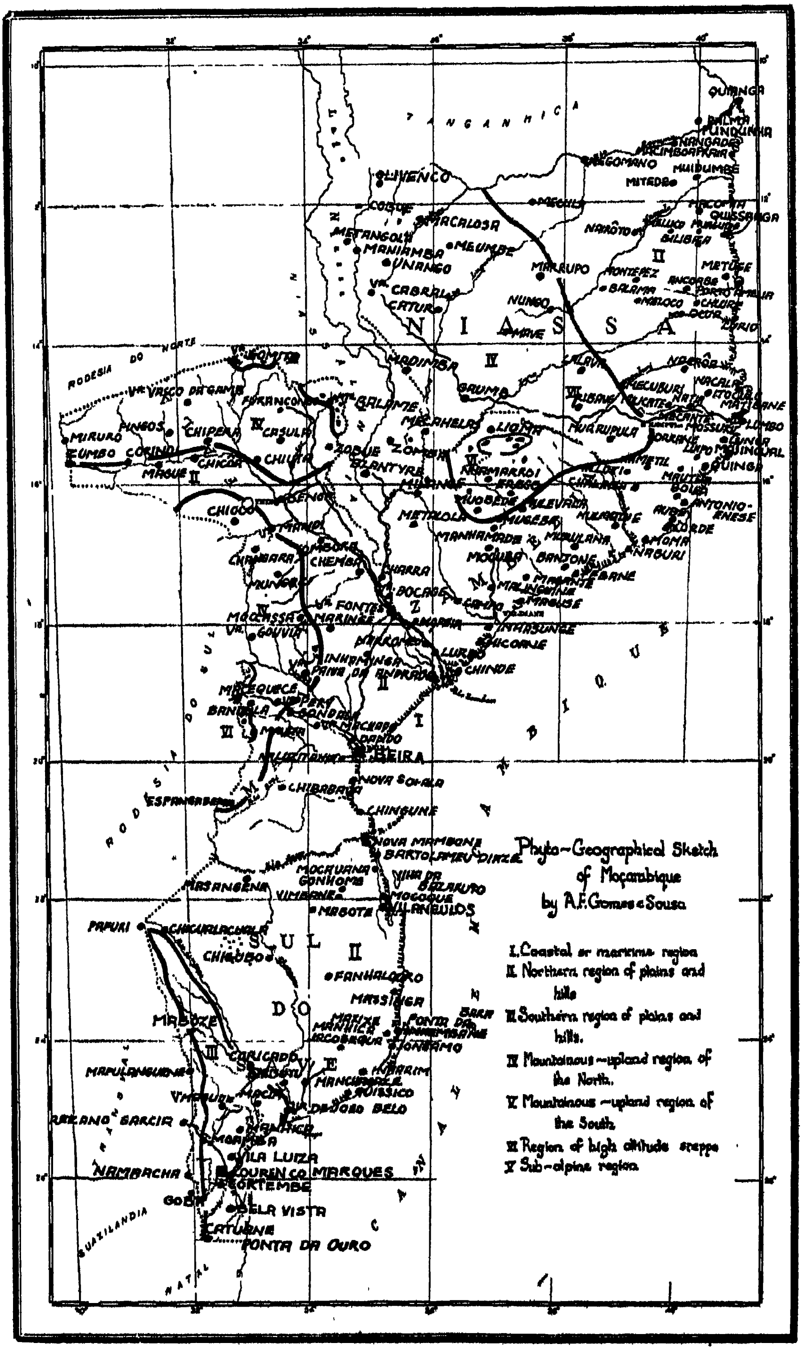
Phyto-Geographical Sketch
of Moçambique
by A.F. Gomes e Sousa
I. Coastal or maritime region
II. Northern region of plains and hills
III. Southern region of plains and hills.
IV. Mountainous-upland region of the North.
V. Mountainous-upland region of the South.
VI. Region of high altitude steppe
V Sub-alpine region
N I A S S A
BEIRA
CHINDE
VILANCULOS
BELA VISTA
PONTA DA OURO

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NOTES ON SOME STRUCTURES OF SOUTH AFRICAN AMMONITES.

BY
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Presidential Address to Section D *of the South African Association for the Advancement of Science* ; *Read* 30*th June*, 1948.

Each of the growth-striae of the ammonite shell marks the actual edge of the shell at the time of its deposition and is therefore an old mouth-edge. These mouth-edges are the usual ones. Another type of old mouth-edge has been known in some genera for some time. This forms lines on the shell surface, cutting across the growth-striae and having two or more backwardly directed sinuses of parabolic shape. Because of these shapes the lines are called parabolic lines or anormal mouth-edges ; but as only portions of these lines are parabolic and as their occurrence is part and parcel of the functioning of the animal there is really nothing out of the normal about them and I would rather call them unusual mouth-edges, in contrast to the usual ones made by the growth striae.

These unusual mouth-edges have been studied by Teisseyre in *Perisphinctes*, by Michalski in *Perisphinctes* and *Aspidoceras* and by Stieler in "*Dipoloceras*", and they have further been found in the Nautiloid genera *Gyroceras* and *Hercoceras*, in the Ammonite genera *Lytoceras*, *Pleuracanthites* and *Virgatites*, while Stieler has only once found an unusual mouth-edge in "*Pervinquieria*" *inflatum*.

Michalski gives a good figure of *Gyroceras alatum* with its unusual mouth-edges. They run radially from the dorsal part of the shell across the flank and sweep backwards to form a deep sinus just beyond the middle of the flank and then bend forward before crossing the venter. The large backward sinuses on the flank are the remains on the surface of the shell of broad anteriorly hollow transverse outgrowths. Some of these outgrowths have remained intact ; but they are generally broken away mechanically, only their intersection with the surface of the shell remaining. This specimen is an exception to the rule.

The last figure in his chain of argument is one which he has copied from Neumayr of a *Lytoceras immane* (3 p. 71) showing clearly that the unusual mouth-edges of this form are the remains of successive trumpet-like flares of the shell which are ordinarily destroyed down to the level of the usual shell surface.

Stieler explains how the unusual mouth-edges come into existence. He has in hand a fossil which he calls *Inflaticeras cristatum*. If his figure is compared with mine of *Dipoloceras cristatum* Deluc

sp. (5, p. 57, fig. 1) and with d'Orbigny's figure of the same species (6, pl. 88, fig. 1, 2) or with Spath's figures (4, p. 365) it will be seen immediately that his specimen cannot be a *cristatum*, the unusual mouth-edge being quite different to those occurring in Deluc's species. However that may be, the matter is of such importance, that I quote his own words on the beginning and growth of the unusual mouth-edges : (*translated*) : "The animal built normally, sometimes laterally contracting the mouth-opening, (making a) normal rib valley, and again laterally extending, (making a) normal rib. Suddenly a change in construction starts in the vicinity of the umbo. Instead of forwards (the Shell) is now built outwards. The prevention of the normal growth therefore begins in the region of the umbo". (9, p. 302). This is true for not a single specimen from our South African deposits and I believe that the explanation which fits our specimens will also be correct for the specimen which Stieler had in hand.

Petinoceras recuperator occurs in bank 8 of the Umsinene Beds. From the last unusual mouth-edge to the next, the shell has perhaps four ordinary ribs. At each younger rib the thickness of the whorl is greater than at its predecessor. Then follow two or three ribs which suddenly extend much further laterally than their immediate predecessor. The anterior surface of the last of these big ribs drops down practically vertically to near the level of the shell surface behind the big ribs. In between the big ribs the shell surface is inflated. The whole of the shell shows a repetition of this system. This shell therefore, forms a repetition of trumpet shaped portions each of which ends in a swelling and an ultimate flare, which last did not extend beyond the heightened umbilical tubercle onto the umbilical surface.

In *Cechenoceras reversum* the unusual mouth-edges form a broad and shallow sinus on the middle of the flank ; its depth is at the most the thickness of one rib. It shows a sharp bend where the umbilical surface passes into the flank. The surfaces of the sinuses slant obliquely inwards and forwards. The difference between this structure and that of *Petinoceras* lies especially in the lack of a swelling and in the obliqueness of the surface in the sinus.

In the type of *Ricnoceras pandai* five unusual mouth-edges have been observed. They are conspicuous by the fact, that the shell continues regularly till a mouth-edge is reached, then suddenly thickens and after the unusual mouth-edge has been formed, retains a greater thickness than before. The rib forming the mouth-edge cuts off two or three ribs behind it on the ventral side. Its shape is exactly like the other ribs, except that it projects further laterally. The resemblance of this structure to that of *Petinoceras* is one of the reasons why I regard the latter genus to be the ancestor of the Dipoloceratidae.

Dipoloceras cristatum is slightly different. Its whorls grow regularly like those of *Ricnoceras* until the unusual mouth-edge is reached. Then suddenly the mouth-edge flares out very far transversely, practically at right angles to the spiral axis.

In the type *Rhytidoceras elegans*, the ribs of the unusual mouth-edges are possibly parallel with the other ribs on the umbilical surface. At the umbilical tubercle they make a sharp bend backwards, cutting off one rib on the dorsal side. From this bend the mouth-edge forms a broad shallow sinus, the surface of which lies flatter than that of Cechenoceras. After the mouth-edge the thickness of the shell is suddenly considerably greater than before. This also happens in *R. rotundum* on the young whorls, but later on the increase of the shell is regular.

The unusual mouth-edges of *R. megaera* are very remarkable. The last mouth-edges on the specimen show the following characters: They start at the umbilical suture and run backwards across the umbilical surface, cutting across two ribs. The sinus cuts across two more, so that on the dorsal side at least four ribs are cut off. On the ventral side perhaps ten ribs are cut off, leaving only a matter of two or three ribs before the sinus of the next unusual mouth-edge is reached. Stieler's explanation, that the change of growth started at the umbilical suture is not applicable here, for after the growth of the ribs had been interfered with on the flank, normal formation of ribs continued on the umbilical surface and at least four ribs were formed there. This specimen clearly shows that the trumpet-flare started with the sinus on the flank. While the normal growth continued along the umbilical portion of the shell and over a gradually narrowing strip along the keel, the trumpet-flare grew outwards while it extended its sides gradually towards the umbilical suture and towards the anterior end of the keel. Forward growth at the umbilical suture was held up until the ventral portion of the flare was finished. This flare therefore forms a very deep sinus with an extra little sinus near the middle of its depth. From each unusual mouth-edge onwards the thickness of the shell is suddenly greater than before.

Deiradoceras prerostratum Spath sp. shows unusual mouth-edges which start on the umbilical suture and run obliquely backwards over the umbilical surface, cutting off one or two ordinary ribs. At the umbilical tubercle the mouth-edge turns sharply backwards to form the sinus, thereby cutting off another rib. The sinus is broad and shallow. We have here an unusual mouth-edge of a similar structure to that of *Rhytidoceras megaera*. Here also the trumpet-flare must have started on the flank, for the ordinary shell in the dorsal region continued untill the flare eventually crossed its path.

This type of unusual mouth-edge also occurs in *D. varinodosum* and *D. exilis*.

The Brancoceratid *Terasceras politus* comes from Bank 8. On one of its inner whorls there is a swelling of two ribs, starting from one umbilical tubercle and rising high above the general surface of the shell. The groove between the ribs is also elevated high above those before and behind. This swelling is a part of the unusual mouth-edge. *T. crassicostatum*, *T. cariniferum* and *T. corpulentum* have at different intervals on very young whorls

a rib which is much thicker than the others and which is an unusual mouth-edge. These thick ribs have a steep posterior surface and a slanting anterior one. The thickness of the shell in front of the thick ribs is greater than that behind.

Another Brancoceratid, *Hysteroceras strangulatum* shows two ribs, forking from an umbilical tubercle, which with their enclosed groove, stand out higher above the surface of the shell than the neighbouring ribs. This is the swelling at the unusual mouth-edge as we already know it from *Petinoceras* and other genera.

In *H. venustum* the first unusual mouth-edge occurs at an umbilical diameter of 1½ mm. on a smooth flank. This specimen has five unusual mouth-edges, of the following shape: A fine line runs from the umbilical suture upwards and forms a backward sinus on the flank. The rib bearing this line is steep behind and its anterior surface slants towards the surface of the shell.

H. famelicum shows on an umbilical diameter of 2 mm. a sudden sharp tubercle on the flank which distorts the umbilical suture with the next whorl. Another tubercle only occupies about two-thirds of the flank and also dents the following whorl. The tubercle is formed by two surfaces, a very steep posterior one and a gently sloping anterior surface. The section between these two surfaces is U shaped with the opening forwards.

In *H. africanum* the umbilical suture of its last whorl, and a quarter of a whorl before that, shows eight deep dents, caused by high ribs. The last of these stretches across the whole flank. It projects so far laterally, that it equals about half the thickness of the next whorl. Its posterior surface is steeper than its anterior one. This unusual mouth-edge is in every respect similar to that of *Dipoloceras cristatum*. This is very remarkable as *Dipoloceras* does not occur again after Bank 11.

In the Brancoceratid *Komeceras acuticostatum* an unusual mouth-edge has the shape of a high rib, steep behind and more slanting in front. It is so high that it dents the following whorl for about one third of its umbilical height. A remarkable difference with other *Dipoloceras*-like mouth-edges is the fact, that the rib has an umbilical tubercle.

The first smooth whorls of *K. ornatum* suddenly bear a high rib which makes a deep dent in the next whorl and following this the shell is very much thickened. The back of this high rib is a steep surface and above this is a sharp edge which shows a fine mouth-edge line. This makes a backward sinus on the flank and runs downwards and forwards on to the umbilical surface at an angle of 45 degrees. The whorl after this first mouth-edge shows four more, each bigger and better developed than the first. The last one dents the next whorl for about a third of its umbilical thickness. Altogether this specimen shows seven unusual mouth-edges, the last one at an umbilical diameter of 4 mm.

Askoloboceras is a very remarkable form. It has a number of unusual mouth-edges, especially on its last whorl which has a

diameter of less than an inch. These unusual mouth-edges have the shape of an ordinary rib which is somewhat thickened. On coming down from the venter and nearing the umbilical suture, there being practically no umbilical surface, the rib bends forwards and reaches the umbilical suture two ribs further forward. The first rib in front of the mouth-edge runs up against it before reaching the umbilical suture, while the second one joins its end on that suture. Nothing has been found so far in South Africa which in any way resembles this structure.

The different genera of the Brancoceratidae discussed here have varying types of unusual mouth-edges. In the genus *Hysteroceras* those of the older forms differ from those of later date. The family has unusual mouth-edges which are similar to those met with amongst the Cechenoceratidae, the Dipoloceratidae and the Pervinquieridae. And this is what one might expect in a family which is thought to be the ancestral family of the other three.

The family Pervinquieridae lived at the time when the highest known beds of the Umsinene Zone were deposited. As far as I am aware the family only contains two genera at the moment, the genus *Pervinquieria* consisting of a large number of species, while there is only one species in the genus *Ameleceras*. In some species no unusual mouth-edges have been found, probably because the young whorls are not known and the unusual mouth-edges only occurred on these. In other species the mouth-edges occur on a large diameter.

In *P. multicostata*, there is an unusual mouth-edge on a diameter of about an inch. It consists chiefly of a narrow long sinus lying flat on the middle of the flank. The rib in front of the sinus has a tubercle halfway between the middle of the flank and the row of umbilical tubercles. The unusual mouth-edge runs from this tubercle to the umbilical suture, cutting off a rib behind it.

The type of *P. nodoso-costata* shows unusual mouth-edges at a diameter of 3½ inches. One of them makes a shallow sinus on a rib. From there the mouth-edge line bends sharply forward on its dorsal side until it strikes the following rib which it follows dorsally for some distance. At a place where the thickening for the umbilical tubercle would start in an ordinary rib, the mouth-edge line makes a U bend and then disappears. From this point to the umbilical surface the rib is very low and it contrasts strikingly with the high tubercles of the other ribs. The unusual mouth-edge immediately behind the one under discussion shows a very fine riblet in this region, running down from where the mouth-edge line strikes the rib in front of the sinus, to the umbilical suture. The thick rib in front of the sinus is suppressed in this region, the fine riblet taking its place. It is parallel with the growth lines and it no doubt represents the mouth-edge line. On the ventral side of the sinus the mouth-edge line crosses four more ribs. Another referred specimen of this species still possesses its extremely young whorls, which are smooth. At a diameter of some 4 millimeters the whorl has four tubercle-like ribs, unusual mouth-edges, which

make a deep dent in the following whorl. These "high-rib" mouth-edges are similar to those described for example from *Hysteroceras famelicum* and *Dipoloceras cristatum*. However, on a diameter of $\frac{3}{8}''$ there is a sinus, lying flat on the middle of the flank. There are five of these before the diameter is $\frac{5}{8}''$ and then there is still a whorl and a half before the end is reached. The surface of the shell immediately adjoining the posterior side of the unusual mouth-edges of which the sinuses lie flat on the shell, stands steep, so that the mouth-edge lines form the edge of a rise. These unusual mouth-edges must represent trumpet flares of the shell resembling those of *Rhytidoceras megaera*, the flare also extending far along the keel. They differ especially from those of the mentioned species in that they do not cut across the ribs or growth lines on the dorsal side.

The unusual mouth-edges of *P. ordinato-costata* are similar, *P. scobina* shows two unusual mouth-edges on its last whorl, and it has, apparently, a similar trumpet flare to that of *P. nodoso-costata*.

P. geniculata shows one sinus while *P. fluctuato-costata* shows two unusual mouth-edges on its last whorl. In *P. ornata* the surface of the sinuses slants forwards as usual.

P. adelei shows four unusual mouth-edges.

An as yet undescribed small *Pervinquieria* of about an inch in diameter shows some beautifully preserved unusual mouth-edges on its younger whorls. They show clearly, that the dorsal portion of the unusual mouth-edge, as it passes down the umbilical surface from the sinus, does not run parallel with the growth lines but cuts across them at a very sharp angle. This angle is so small that, in not such well preserved specimens one is inclined to believe them parallel.

Reviewing the genus *Pervinquieria* we find that the unusual mouth-edge line forms a sinus, mostly on the ventral side of the flank and sometimes on the whole flank, that its dorsal portion makes a very sharp angle with the ribs and growth-lines and that its ventral portion cuts off three or four ribs in front.

The genus *Ameleceras* in its type species of $2\frac{1}{2}''$ diameter shows fourteen unusual mouth-edges. The sinuses lie on one or two ribs; their posterior border is steep and high; the surface within the sinus is flat and it bends down sharply as it emerges from the sinus. The sinus covers practically the whole flank.

On a still smooth whorl of *Erioliceras mutabilis* (a new genus of Pervinquieridae), there is a high rib, denting the next whorl deeply. This is apparently an unusual mouth-edge of the *Dipoloceras* type. On the next whorl there is a sinus, lying on two ribs, with its dorsal border apparently raised higher than the rest and lying over the middle of the flank. *E. errabundum* also shows a single high rib on its very young ribs which makes a deep dent in the next whorl.

From all the genera and species discussed in the above it appears that the *Dipoloceras* type of unusual mouth-edge belonged to a trumpet flare without a sinus. Having only the thickness of a

rib this type of flare cannot have lasted a long time. The unusual mouth-edge type of *Cechenoceras* and *Rhytidoceras* must have started building its trumpet flare at the hindermost portion of the sinus. According to Neumayr the flares of *Lytoceras immane* also started on the flanks and not at the umbilical suture (3, p. 105). The flare grew outwards and sidewards as the growth of the rest of the shell proceeded forwards. In *Deiradoceras* the fact that some ribs are cut off on the dorsal side proves that this portion of the shell grew on while the growth in the sinus was directed in another direction. *Rhytidoceras megaera* is very instructive. The unusual mouth-edge started with the sinus on the flank. In the meantime the dorsal portion of the shell grew on and built two more ribs ; eventually this growth was also stopped by the flare. On the ventral side the long keelhorn was already projecting far forward. When the flare started growing at the sinus it apparently also started along the horn. While the flare was growing, the horn kept growing forwards. But the ribs on the previously built portion of the horn were of course interrupted by the flare.

The flares of *Pervinquieria* and its allies were built in a similar way to those of *Rhytidoceras megaera*.

After having enumerated the different genera and species possessing unusual mouth-edges and having described their differences of structure we may well ask how the animal proceeded with the growth of the shell after the mouth-edges.

Teisseyre is of the opinion that certain portions of the mantle surface closed the sinuses (1, p. 571). Michalski also states that the mantle closed the hollow spines below (2, p. 127). He also describes some cases in which fine growth lines are visible immediately in front of the unusual mouth-edge and following more or less its sinuosities. Stieler states definitely that the external layer of the shell is formed by the edge of the mantle and he has found no reason to accept Michalski's assumption that the shell was formed as a plastic surface and was afterwards pressed into folds (9, p. 295). His whole description of the forming of the flare is based on the assumption that the shell is only built further by the edge of the mantle depositing very thin growth strips on existing shell matter. The unusual mouth-edge line is, according to Stieler, the line to which the individual growth strips were attached on the inner side of the trumpet flare (9, p. 308). He explains, that the hollow ear of *Gyroceras alatum* is closed below by the mantle edge, a number of growth lines being present here. However, the hollow spines of *Sonninia sowerbyi* are closed below by a deposit of the mantle when the mantle-edge was already further forward. Every septum proves that the mantle surface can deposit nacreous material over open places, the only condition being apparently a possibility of contact on three sides (9, p. 314). The sinus of *Perisphinctes evolutus* has presumably been closed by the mantle surface (9, p. 315). The unclear ribs of this portion were formed by the mantle being fixed on both sides of the sinus to rib ends and being consequently bent into rib-like folds (9, p. 316).

Stieler is the only one who tries to find proof that the mantle surface can actually deposit shell substance. He finds it in the septa and in the closing of the hollow spines. In our material there is a specimen which brings undoubted evidence that the whole mantle can deposit shell material.

The type of *Deiradoceras varicostatum* v. Hp. is a very remarkable ammonite. The specimen has a diameter of 6¼″. It showed signs of sutures near the end of the last whorl and it was attempted to develop these at from two to three inches from the end. At the umbilical suture this was easy; but the more one proceeded towards the keel the deeper one had to dig to get at them; at the keel the sutures were found ⅜″ below the shell. As these sutures are the lines of section between the shell and the septa, it is most remarkable to find them at that depth. But still more remarkable is the fact that just before the sutures are uncovered another thin shell had to be removed. Two sutures were laid bare and then the question arose what the meaning of this was. Studying the specimen carefully it was found that the section at the end of the whorl showed two shells, one within the other. The tops of their keels are about ⅜″ apart from each other. On the middle of the flanks the two shells apparently meet. At the umbilical tubercle there are apparently still two shells in very close contact with one another, for the umbilical tubercle with its base easily comes off the specimen. This looseness of the umbilical tubercle stretches backward till the seventh from the end of the whorl, which is just half a whorl. Where the outer shell has been removed it is seen that the inner shell vaguely indicates the ribbing and tubercles of the outer shell. Moreover there is a broad shallow groove stretching obliquely across the ventral portion of the inner shell from near the keel in front to the top of the shoulder behind. The keel of the outer shell is high and narrow, that of the inner shell low and broad. These are the salient facts, which may be explained as follows: When the shell had reached the stage that the animal was using its last half whorl as living chamber, some malady attacked the animal, resulting in a great reduction in size and its mantle parting from the ventral portion and the flanks of the shell. When it had reached the limit of its reduction, the mantle of the animal provided it with a new, smaller body-chamber, inside the old one. It also started building new septa within the new body-chamber and moving gradually forwards. In this way the new shell within the old body-chamber was eventually filled with septa. Whatever the cause of the animal's reduction, one fact stands out clearly, the animal was provided with a new body-chamber and this had to be done by its body mantle. It is impossible to imagine that the new shell was built by the mantle edge which would have had to be folded backwards for the purpose, right to the posterior end of the old living chamber. This would then also account for the vagueness of the ribbing and tuberculation of the new chamber.

Let us now have another look at *Rhytidoceras megaera*. There is the deep sinus cutting off four ribs dorsally and at least

eight ventrally. But of the four dorsal ribs three correspond with only one rib within the sinus, and this one corresponds with two on the ventral side. The idea of Stieler's that the mantle was fixed on both sides of the sinus to rib ends and that it was thus also bent into ribs, apparently does not fit in here. The next rib within the parabolic unusual old mouth-edge more or less closes the sinus off. It ends ventrally opposite the ventral margin of the sinus. Here it is separated from the rib of the unusual mouth-edge by a groove which runs along the front of the mouth-edge from the umbilical suture to the beginning of the sinus. The groove continues over the flank like an ordinary rib valley. On the ventral side this rib ends exactly opposite a rib-valley of the cut-off keel section and it connects with the ribs in front of and behind the valley. Then follows another rib which dies out at the groove, halfway down the umbilical surface. This rib branches into two on the middle of the flank and these branches connect up with cut-off ribs on the keel section. The next rib starts at the umbilical suture and also runs into a valley on the ventral side where it also connects up with two ribs. The next rib runs right through from suture to keel and it apparently does not cross an unusual mouth-edge line near the keel. After this there is an irregularity and then follow two ribs on the ventral side which run into one on the flank where the rib is disturbed by the sinus of the last unusual mouth-edge, the one described being the second from the end.

All the ribs and valleys within the space of this parabolic unusual mouth-edge are vague within the sinus and become less so towards the front. All the ribs, even those within the sinus, are ornamented, especially on their posterior surface with numerous small spiral riblets. These riblets are not seen at the bottom of the rib valleys and they do not seem to occur on the cut-off ribs on the dorsal side. There is some spiral ornament on the umbilical portion of at least the last rib before the last unusual mouth-edge. The whole parabolic surface lies higher than the preceding one. There are no growth-lines visible on the flank. The surface of the end of the shell is sufficiently well preserved to have retained them if they had been there. There are, however, growth-lines on the three or four cut-off ribs on the dorsal side. Younger whorls show growth-lines on two or three ribs behind the next unusual mouth-edge.

That the ribs within the unusual mouth-edge should be explained as Stieler does, that they have been formed by the fixing of the mantle to the cut-off rib ends, cannot be accepted here. In fact sometimes the ribs run into valleys and they have to branch at their ends in order to connect with cut-off ribs. This stretching of the mantle between high points on opposite sides can moreover never explain the occurrence of the finer spiral ornamentation. This would disappear if the mantle were subjected to transverse stress. Its presence is on the contrary a proof that there was no stretching of the mantle between high points. Their presence proves further, that they were present in the mantle as one of its

inherent properties. However, if these finer riblets were in the mantle, there cannot be any reason why the coarser ribs, the more or less radial ones, were not preformed in the mantle as well. Objections to this in the past were apparently connected with the softness of the mantle and with the idea that all undulations of the shell were formed by the mantle-edge. Of course, preformed cannot mean absolute rigidity, for in that case, apart from growth, all the surfaces enclosed within the parabolic mouth-edge line would be similar.

The lack of growth-lines is an indication that the surface was not formed by the edge of the mantle. It is not clear where the edge of the mantle started; but apparently the last two ribs of the surface may be ascribed to it.

One can now conceive the growth of the shell to be as follows: Suddenly on the middle of the flank the animal starts building the shell outwards. Along the umbilical suture the mantle-edge builds a few more ribs normally and then stops because here also the flare is started. The keel has produced a projecting horn which is already some eight or ten ribs ahead of the rest. Gradually the flare also extends into this region and cuts off the ribs started here. As the flare grows the keel horn is extended further. Now the time arrives when there is no further use for the flare. Then the animal being sttached dorsally to the preformed shell and ventrally having the support of the horn, emerges for some distance from its living chamber. At the same time the body swells out. The mantle of the animal now attaches itself to a line on the inside of the flare which lies further away from the axis than the preceding surface. Then the mantle starts forming shell material and as soon as this is formed the mantle-edge starts depositing on its anterior edge. After a few ribs are formed by the edge the animal starts forming a new flare.

If the shell grew in *Rhytidoceras megaera* in this way then it grew in a similar way in *Deiradoceras varinodosum*. The large surface within the parabolic line shows four ribs in the sinus; the fourth starts at the spot on the umbilical suture where the unusual mouth-line starts, and this rib closes the sinus. These ribs are much less clear than the rest and are therefore a product of the body portion of the mantle. Here also all the ribs show spiral ornament and as in *Rhytidoceras megaera* we have to accept here also that the corrugations, ribs as well as spiral ornament, were preformed in the mantle, in a similar way as the large and coarse ribs and the tubercles of *Deiradoceras varicostatum* were vaguely preformed in the mantle which formed the walls of its second living chamber.

It is possible that in *Cechenoceras* the edge of the mantle connected up with the flare and built the sloping surface within the sinus. However, after the explanation given above it is very probable that this portion was built by the mantle surface. After the flare was formed the body moved forwards and distended somewhat. The mantle then attached itself fairly high on the

flare and built the sloping surface in and immediately in front of the sinus, while the mouth-edge was already further away. In favour of this explanation is the vagueness of any ribbing which occurs in this region.

The same explanation holds for *Petinoceras*, *Terasceras*, *Hysteroceras*, *Komeceras*, *Ameleceras* and *Erioleceras*. In *Askoloboceras* the flares were bent extremely far backwards. The explanation for the unusual mouth-edges in *Mortoniceras* is similar to that for *Rhytidoceras megaera*. Whether the explanation is also valid for *Dipoloceras* is not quite certain yet. In its favour counts the fact that many of the described species have *Dipoloceras*-like mouth-edges in their young stages which later change into those for which the given explanation holds. Probably the mantle-edge of *Dipoloceras* built the flare high up and then let go completely. The body then protruded and some part of the mantle surface attached itself to the edge of the flare, further therefore, than is usual in other species.

Seeing the development of the shell in this way it is no longer remarkable that the "last mouth edge Type" does not occur earlier. The last mouth-edge is formed by the animal in its adult stage or in senility and that is why its type is not met with in small shells. Shells with a "last mouth-edge" are no doubt full grown.

In the foregoing I have tried to show that unusual mouth-edges occur in very many more species and genera than was hitherto believed. It has also been demonstrated that this phenomenon is different in different groups and further a new explanation has been given with regard to its development. This explanation was also based on facts which have been obtained from a remarkable pathological specimen which is made known for the first time.

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PANORAMA OF PREHISTORY IN MOZAMBIQUE.

BY

ENG. L. A. BARRADAS.

Presidential Address to Section "E" of the South African Association for the Advancement of Science.—Read July, 1948.

I have undertaken to write the Presidential address for Section "E" of the S.A.A.A.S. with real pleasure, as I feel that the honour of presiding over this section has been conferred upon me not merely in my individual capacity but more specially for the inclusion of a Portuguese worker in the list of distinguished presidents of an Association which is notable for its scientific work.

I especially wish to express my appreciation of Prof. van Riet Lowe's support of the call made upon me to fill this position and I also wish to render homage to the Council and members of this Association.

I regard with admiration the important prehistorical studies which are being made in the Union of South Africa of subjects in which that country is a leader of all who appreciate the supreme importance of the early appearance and development of Life in Nature.

Such an outstanding position as regards prehistory is due, not only to the numerous discoveries of important archaeological sites of varied cultures, rock paintings, inhabited caverns and palaeontological finds such as those of Taungs, Sterkfontein, Kromdraai and lately those of the Makapansgat Valley, but also to the distinction with which these studies are conducted.

These great and varied archaeological remains of special importance because of human relics which will surely reveal many things, are being studied by a great number of scientists who are experts in their particular spheres, as, for example, Dr. Robert Broom, Prof. van Riet Lowe, Prof. R. Dart, Dr. Cooke, Mr. Goodwin, Dr. Wells, Prof. King, Mr. Malan and many others as well as by eminent foreign experts like Prof. the Abbé H. Breuil.

Having included Dr. A. L. du Toit's name in this list at a time when he was still alive, I wish to take this opportunity of expressing my sorrow at his decease, and at the grave loss to science of his great proficiency, his willingness to teach, and his good nature which I had the privilege of witnessing during the Pan-African Congress of Prehistory at Nairobi in January last year.

The study of prehistory seems to be shifting from Europe to Southern Africa, the "paradise of prehistorians", as suggested

by Prof. H. Breuil. It is to be expected that some light will be thrown on the origin of man in this continent, the main reason for the interest shown by the countries which are sending their research parties here, such as the present "University of California Africa Expedition". In this respect the effective government protection of prehistoric research in this country must not be overlooked, as official personnel are engaged in field surveying, conservation of archaeological remains and in assisting in the publication of new facts, and even by means of university courses.

Mozambique, with a neighbour of this character, derives both direct benefit and stimulating influence, and a desire arises for scientific intercourse on matters of common interest; Mozambique feels the impulse to join in research corresponding to our neighbours' achievements, although their activities and ours in this scientific field are on different levels. Whereas at present it can be said that we are still taking our first steps, even with some hesitation, research in South Africa has reached maturity.

The Union of South Africa has its problems of prehistory and we have ours; but it is desirable to ascertain what correlations exist between them, as very often the solution of one problem may throw light upon the solution of others in a neighbouring country.

Our Colony's interest in prehistory, although otherwise shown than in the Union, provides evidence of its scientific deserts. I think that it may well contribute through its investigations towards the solution of many common problems particularly in regard to the prehistory of southern Africa *as a whole.*

It is therefore with pleasurable anticipation that the Colony of Mozambique wishes to co-operate with the Union in prehistoric research, not only by endeavouring to determine, safeguard and disclose the scientific wealth within its boundaries which may thus become a treasure of knowledge for all, but also by building up and retaining an intimate contact with neighbouring workers for the advancement of science. The fact that this congress is taking place in Mozambique is already an important step towards the recognition of common scientific interests.

In this address, prehistory is visualized, in the first instance, as the history of the rise and development in living objects of a faculty which we term 'intelligence'. This faculty although existing in some animals in an infinitesimal degree, has already reached in some members of the human genera a summit, achieving an almost supernatural creative and destructive power which may well be regarded as the greatest marvel in existence.

There are to-day different human races upon the earth, and many others have become extinct; which of these have been our ancestors, and where the primitive origin of humanity lies, are surely exciting problems, still very far from being solved.

I think therefore that interest in the science which deals particularly with the genealogy of humanity, is perfectly understandable.

It has been claimed that France was the first home of prehistory, the study of which spread to other countries in Western Europe. In 1847, Boucher de Perthes, the French archaeologist and pioneer of prehistory, published his first works on the palaeolithic implements found on the Somme terraces. This was thought so important by the English students—with whom this was a favourite subject—that, according to van Riet Lowe, Gordon Child, referring to these finds, used the following words which established Prehistory as a science: "In 1859 prehistoric archaeology, and therefore history based upon archaeology, began to form a science on its own."

In 1858 when prehistory had hardly established itself fully in the field of science, South Africa obtained its first discoveries in the terraces of the Fish River in the Cape Province. It is with due pride that the South African prehistorians point to Colonel T. H. Bowker's pioneer work on prehistory, shortly after the first descriptions of a scientific nature on the discoveries in the Somme Valley.

Portugal also gained a period of repute from its pioneers of this science like Pereira da Costa, Nery Delgado and, above all, Carlos Ribeiro. In 1864 Ribeiro had published scientific work referring to the quaternary formations of the Tagus and Sado River basins, and in 1871 he noted the famous Tertiary eoliths in the formations of Ota which gave rise to discussion between the scientists of that time, resulting in the IX International Congress of Prehistoric Anthropology and Archaeology being held at Lisbon in 1880. The relationship between the Homosimius Ribeiroi" and the maker of these eoliths was made known, a matter which has been clarified to-day, in great part as a result of the work of the Abbé Breuil who recognises the authenticity of the implements but places them in the Quaternary.

Under these circumstances Europe was taking the lead a century ago not only in the field of archaeological investigations, but also in that of philosophic speculation, in a period when Creationism supported at the time by eminent men like Cuvier—was already giving way to Transformism, supported by scholars led by Lamarck and Charles Darwin.

The first finds of chipped stones in the Somme Valley together with remains of extinct animals, and also the discoveries of extinct human races, like that of Neanderthal, in 1857, when for the first time science was faced with the fossil of a man of somewhat simian appearance but with marked differences from actually existing man, caused much confusion in what was hitherto believed concerning the first steps of humanity. From simple curiosity an exciting discussion arose in the field of religion and philosophy, eliminating beliefs rooted in legend and tradition but based on

dogma, and finally accepting the origin of man on a basis of scientific order.

In this contest beweeen observations and the belief that Adam was made of clay 4,000 years ago instead of having an ancestry of over a million years, man's primitive origin was placed side by side with the descent of the hominids from Tertiary primates. Prehistoric science has evolved greatly and is nowadays no longer based upon museum specimens, or on some fantastic speculation of a philosophic or religious order, but upon a great diversity of other sciences, like Archaeology, Geology, Palaeontology, Ecology, Anthropology and Ethnography, giving it an essentially scientific nature. It is not to-day a subject for amateurs, but the product of collective endeavour, though prehistory was established through individual effort and by private associations of a cultural nature, and finally became a science officially recognised and sponsored by the State itself.

Besides simple publication of special interest only to a learned public, there are associations, reviews and even congresses of a private or official nature, which in detail or in a wide general scope give a basically scientific character to prehistoric matters.

The States themselves, taking Prehistory under their sponsorship, issue laws protecting archaeological treasures, subsidize field and office work, collect archaeological relics in museums, proclaim places of prehistoric interest, publish whatever they find, and even, in many countries, introduce courses on human palaeontology in the universities.

We can point to the Union of South Africa, where General Smuts' sympathy with this science has contributed largely to official protection. As a devoted prehistorian he ranks as one of the pioneers of Mozambique's Prehistory, exemplified, for instance, in his palaeolithic discoveries in the Portuguese Pafúri.

Examples of this nature serve to show clearly how the culture of the mind is not incompatible with functions of an essentially utilitarian order and of great responsibility.

CHAPTER II.

Our Prehistoric Wealth as it Stands To-day.

The first news about the Prehistory of Southern Africa was disclosed by Portuguese chroniclers soon after their arrival in this part of Africa.

Joaõ de Barros, according to the work "Prehistoric de Moçambique "by Prof. Mendes Correia, acknowledged in 1552, the existence of old walled structures, or Zimbaues, spelt "Sybaoe" in the Portuguese language of the time. According to Prof. Santos Junior—and this seems nearer to the truth—this chronicler was referring to the ruins of Inyanga in Southern Rhodesia, close to the Portuguese border.

Also in the XVIII century (again according to Prof. Mendes Correia) the prelate of Mozambique, in answer to a request by

the Academia Real de Historia Portuguesa concerning the Zimbaue ruins, furnished information in 1721 relating to the existence of drawings on rocks exhibiting dogs, camels and other animals, as well as some inscriptions. These are no doubt the first references to the rock paintings of Southern Africa.

Later, due to historic impediments, we had to turn our attention away from cultural matters concerning this Colony, and it is only at the beginning of this century that, thanks to the observations by pioneers of this study, some Portuguese and some foreigners, Prehistory began to acquire a scientific character, and later official protection.

Prehistoric discoveries, ranging rom the Pre-Palaeolithic to the Proto-Historic, are already numerous, some of considerable value, and many are now adequately recognized and studied.

The Colony of Mozambique proved to be rich in relics and prehistoric sites, in a great diversity of cultures from the most primitive to those which had probably come into contact with those found here by our first navigators.

While Mozambique has not proved as rich in palaeontological wealth as South Africa, Kenya, or Southern Rhodesia, discoveries are probable when our quaternary terraces and caverns are fully examined, as many geological and archaeological objects, in a very complete sequence, are already available for the study of the Quaternary.

Mozambique can be divided archaeologically into two large zones, separated by the Save River.

In the Southern zone one notes the absence of walled sites or even of rock paintings or engravings, as well as of traces of the neolithic. This zone, however, with its numerous and varied palaeolithic cultures and great diversity of quaternary terraces which occupy large areas at many different levels and vary largely as to the time of their formation and the sources of their composition is of use to the study of the course of the Quaternary in terms of marine planes and climatic variations—and consequently to the study of the correlation between Archaeology and Geology.

In the Northern zone and in the central part of the Colony, in Manica and Sofala, between the Busi and the Zambesi, but not in the Southern zone there are many traces of what appears to be a corridor of penetration into the interior of Africa, connected with Southern Rhodesia. This suggests the possibility that gold exploration might have taken place in this part of Africa. In some mines of this metal, like Machingsa, Chifumbazi, and Mutende, there are signs of explorations by primitive methods, and at different places copper ornaments (e.g. amulets) probably of this period, have been found. Iron exploration, revealed by the presence of scoriae and clay pipes should also not be neglected.

This corridor seems to be very rich in archaeological signs, and seems to have special characteristics, showing affinity to

Rhodesian archaeology, the study of which could be completed here.

There is also in this zone an abundance of palaeolithic stations, but, from the Zambesi to the North, these fail a good deal, probably owing to the poor character of the rocks—usually of milk quartz—which make up the fluvial terraces.

. . . .

Let me describe very briefly the archaeologic sites known in Mozambique to-day:

(A) WALLED SITES (ZIMBAUES).

The following are recognized, although all have not been studied: Walls of the Sonjo Mountain, of Zembe, of Mavita and of Nhangara Rotanda (or "Doors of Vulcan", as they were called recently);

(B) ENGRAVINGS AND ROCK PAINTINGS.

We have among others, not yet studied but only recognized, the following: Cazombo, Chifumbare, Chicolome, Chauremba, Mavita and Vumba Mountains.

(C) NEOLITHIC.

A neolithic implement was found some time ago in the Busi riverside and was described by the late Professor J. Leite Vasconcelos.

Neolithic implement finds are frequent in the vicinity of VI Ia Pery—the site I cannot determine—and some of them are displayed in the Alvaro de Castro Museum.

This culture is undoubtedly related to the identical one in Southern Rhodesia.

(D) PALAEOLITHIC.

Due to the absence of a precise division, the traces left by man in chipped stones, from the most remote to poorly defined times which are probably not very far distant, are grouped under this period.

The Later Stone Age has already been recognized but the study is still in its initial stage.

There are different Kitchen-middens along the coast, some appearing to be quite recent, others which may be considered as belonging to the end of the Palaeolithic, with typically dark soil, and still others which seem more ancient, probably belonging to the Later Palaeolithic.

Stations are very frequent and there is sometimes an abundance of implements, which have already been called "Palaeolithic Complex of the Sabie" and which should correspond with the mixture of the Middle Stone Age and others, preceding or following these.

We must add that these sites and their cultures have not yet been conveniently studied, but regional varieties seem to exist.

Coming into the Old Palaeolithic, various cultures of the period are frequent, forming a very complete range.

The Fauresmith is known but not studied.

The African Advanced Acheulean, with some typical stations, has a special similarity with that of the Tugela in Natal, according to Professor van Riet Lowe.

The African Abbevillian-Acheulean is also frequent in quaternary terraces of fluvial origin.

The African Abbevillian is typical, and in certain places is found in geological formations. It is notable from the beginning of the Abbevillian to the end of the Acheulean, and a predominance of block on block technique seems to be a regional characteristic, found in very coarse implements of the Abbevillian, and also in some of the Acheulean in a much more perfect form.

Of the African Pre-Abbevillian there are various stations with industries of the Oldowan.

If we consider the Kafuan (also found in different places, although not forming typical stations) as a culture preceding the Oldowan, traces of it are found that are difficult to classify, as can be expected.

Of Palaeolithic times the following sites are known at present as the most interesting:

Terraces of Zambesi, Busi, Limpopo, Elephants River, Incomati; Magude, Mangulane, Sunduine, Novene, Snake Hill (Cerro das Cobras), Revez Duarte, Changalane, Coba, Posto Velho da Moamba, etc. These are the archaeologic stations known at present as of most interest, but second rate stations are frequent in the Quaternary formations of the above mentioned rivers and streams, some of which have accumulations which still require study.

CHAPTER III.

OFFICIAL INTERVENTION IN PREHISTORY.

The Portuguese Government, acknowledging the scientific and cultural value of our archaeologic wealth, from the first traces of mankind to modern times, established in 1943, by Legislative Charter No. 825, the Mozambique Monuments and Historic Relics Commission. This charter deals with the definition of monuments and historic or archaeologic relics, with their preservation and with encouragement of their study. The directive body of this commission includes two representatives of Prehistoric studies.

Although this charter is directed more towards the prevention of damage to old fortresses, churches, and other buildings of the earlier period of Portuguese occupation, and of historic value, it also does not neglect our cave riches, rock paintings, zimbabwe pre-historic or proto-historic sites, together with their implements, etc.

The Government Industrial, Geological and Technical Department has voluntarily undertaken the conduct of surveys, local investigations, especially in the Sul do Save, office work, the publication of some surveys which have already been carried out, and also the storage, in its museums in Lourenço Marques and Macequece, of prehistoric collections.

In the Freire de Andrade Museum in this town finds from numerous Palaeolithic stations of the Sul do Save, as well as typical collections for comparative study supplied by the University of the Witwatersrand, by the kind assistance of Professor van Riet Lowe. In the Alvaro de Castro Museum there are Neolithic finds, but in small quantity.

In the Macequece Museum there are Palaeolithic finds of varied cultures and stations found in that region, and others of proto-historic or even historic value which are related to the interesting archaeologic region of Manica and Sofala, where, it is supposed, the first penetration into this part of the continent by non-bantu populations was made.

The Mission Anthropologic da Moçambique, created by the Portuguese Central Government, includes prehistoric studies in its program and has undertaken archaeological surveys of many regions, and found throughout the Colony numerous palaeolithic stations, rock paintings, walled sites, and other sites of interest.

Many of these surveys and observations gave rise to studies which were published in special periodicals. A great variety of palaeolithic specimens was sent to museums on the Continent.

The Sociedade de Estudos da Colonia da Moçambique subsidized by the State, has also taken an interest in these studies, and arranged to deliver lectures and to publish articles in its Bulletin.

Although what has been done officially may not be a very great work, it nevertheless represents, within our means and taking into consideration the short time spent in this field of science, the great interest of the State in protecting our prehistoric wealth from destruction and in facilitating its study.

Meanwhile a new co-ordination of bodies for scientific investigation is expected to come into being, and it is hoped that Prehistory will gain a better position, allowing us to deal more directly with the protection of our archaeological wealth by excavations, and with related studies.

CHAPTER IV.

THE POSSIBLE CONTRIBUTION BY MOZAMBIQUE TOWARDS THE STUDY OF THE PREHISTORY OF SOUTH AFRICA.

It is quite admissible that the palaeolithic cultures of the South of Mozambique have a typical mark dissimilating them from those of South Africa and this was Professor van Riet Lowe's opinion when he established a divisional line determined by the Lebombos and the Drakensberg.

At present the study of our prehistoric cultures is not so well developed as to permit me to imagine the differentiations and correlations that in this respect should have existed between the South of Mozambique and the neighbouring countries.

We only know that we have numerous rich and typical palaeolithic stations, which constitute a very complete sequence of cultures, from the most ancient to the most recent, and some of them may be considered as classic by their significant geologic beds and well defined techniques. But, as I have said, neither has a comparative study of these cultures been outlined, nor have their relations with the South African cultures been fully studied. This work will certainly be of great interest in the future. At present it is too early to establish correlations between our palaeolithic cultures and those of South Africa.

Perhaps, however, it is in the field of geology that our contributions can be very useful in the explanation of many phenomena. Southern Africa may profit by these contributions and they may even help in solving the complex problem of the whole of the Quaternary.

We are beginning to notice a big assembly of factors which acted on our Quaternary formations varying very much in time, space and origin and allowing a close correlation to be established between the climatic periods, altimetric movements of the sea and palaeolithic cultures.

The South of Mozambique is made up almost exclusively of quaternary formations, and this geologic landmark—nearly a third of the area of the Colony, and hardly extending into the neighbouring countries—has its limits on the southern portion not very far from the border line. Its big penetration into the interior of the continent contributes towards the exhibition of very special characteristics by these formations, above all by their diversity, as a consequence of altimetric movements of the sea, climatic variations, the origin of their components, the mechanical factors of their deposition, the altering agents of their composition and constitution, and the course of time itself.

The altimetric movements of the sea have left their mark, either by abrasion, erosion, or sedimentation, at different levels, often at a height of many metres, and many kilometres away in the interior. Climatic fluctuations have also left their signs, either indirectly by the mechanical action of diverse factors, as strong and dry winds, and torrential water acting on the ground elevations, or directly by the change of composition of the soil. In this way we have deposits, from the most ancient to those of to-day, of marine, brackish, fluvial, colluvial, eolian and organic origin.

These deposits have been altered later by mechanical factors, with loss of light components, either by the action of wind and water, or by raising or lowering of certain elements through washing, drag and capillarity, or by having gone through metamorphic changes in composition by silicification, enrichment of Fe, Mg,

minerals, calcination, or alkalization, the latter through the presence of oceanic waters ; on the other hand they are subject to a profound and delayed edaphic and metabolic action, with loss or gain in organic material.

It can probably be said that all quaternary periods have here left their marks. It would appear that there exist five rainy periods and their corresponding marine transgressions with raised beaches of 2, 12, 20, 90 and 120 meters . . . (these figures are subject to correction) ; the latter beaches lying much to the interior of the present coast line, on the eruptive formation of the Lebombos and other hard rocks and with identical beach marks.

Although the rainy periods correspond with much accuracy to the altimetric movements, it is very possible that there is not the same conformity between these phenomena and their repercussion on the formation of the soil. It is probable that the maximum activity in the formation of deposits corresponds, not with any maximum climatic or altimetric conditions, but with the beginning of either pluvial or dry periods, just after a break in the equilibrium, established by nature, between soil erosion and its prevention by the vegetal mantle, as a consequence of climatic change through rain, humidity, temperature or wind. During a period of rainy and hot climate, in which a big movement of sediment is favoured by big falls in precipitation, the soil is protected sometimes quite effectively against this erosive action by its mantles of forest or herbaceous vegetation. The climate having changed, the vegetation must consequently be impoverished, although at a slow rate. Even though, with smaller precipitation, the soil is increasingly exposed, through denudation, to torrential or laminating erosion by rain or wind, it ultimately reaches an equilibrium which will be maintained through the remainder of the period, supposed to be dry and cooler.

A period of heavier and more persistent rains having started again, together with a rise in temperature, torrential waters running through the soil on the embankments and riversides badly protected by vegetation, give rise to deep erosion with the corresponding deposition at other points until through delayed ecologic evolution, the mantle protecting the soil is replaced and in this way arrives at another stage of equilibrium.

The lack of harmony between these maximum climatic fluctuations and transgressions on the one hand (if there is such a harmony), and the maximum geologic activity on the other, can also be accounted for in places nor far from the coast-line. The big deposits, constituting certain fluvial terraces with heavy material when the transgression of the sea was at its maximum, do not seem probably due to the absence of sufficient grade to build up the velocity of the waters, a factor which is essential to the dragging of these materials.

The levels of regression are not distinguishable, but it is to be supposed that probably in compliance with the Hydrographic law, they were very pronounced during the Quaternary.

The big deposits of fluvial origin, especially those corresponding to the first and the second pluvial periods cover large areas and are often of great thickness and contain large stones forcibly rolled. This shows that an enormous drag of lighter sediments must have taken place on a considerably greater scale, with fine sands, silt and clays, which were dragged to the vicinity of the sea, and there were deposited in deltaic and para-deltaic formations, or were carried into the sea itself by the fluvial, tidal and maritime currents, giving rise to extensive areas of marine muds, which were uncovered in later regression, and some of which, of lesser altitude, were again submerged. Soils of this nature constitute to-day a large area from the vicinity of Lourenço Marques to very much North of the Save river. On some of these soils there are typical traces of salt-marshes or even salt works, as in Maquese for example, and as a rule superficial waters in certain rivers, old arms, or lagoons, are salty, as well as the deep waters.

The big sandy formations (nowadays consolidated dunes) follow the coast-line (although sometimes quite far from it) and show also the long and effective action of strong and dry winds on old sand banks uncovered during the retrogressions, of these banks particles were being carried into the interior away from them, as can be seen to-day in the formation of existing dunes.

It all leads to the conclusion that these alternate climatic changes had originated a continuous ecologic evolution. The forest mantles, or thick herbaceous coverings of rainy and hot climates, must have resulted, as has been said, in a denudation of vegetation of the soil during dry periods and the reverse in rainy climates. This seems to be indicated by the present flora. The "Borassus" palm-trees in the region of Sul do Save, very scattered and very rare, are either the advance-guard of a hot climate, or the last elements of a Botanical Complex moving backwards towards the North, as seems most probable. Certain silicified trunks at Maputo, seem to indicate the former existence of species requiring more heat and humidity than the present climate. The presence of gum-copal in raised beaches of two metres also shows that in those soils there existed "Copalferas" or other species, which are only found further north to-day.

The marshes (peat-mosses) which have a well-defined edaphic limit to-day, and which appear calcified in the river das Pedras, seem to indicate that the present climate has already extended more to the north and may be on the way of regression ; possibly later, the outlet of that swamp to the sea being obstructed by sands it changed into a lagoon with water very heavy with lime from local limestones which in that way fossilised the organic waste material, where one can recognise "Phragmites", "Pagyros", gramineae, and even dicotyledonous trees and where sometimes gasteropods are found. It is therefore to be admitted that the zone of the marshes has suffered fluctuations in the northern limits.

Unfortunately, however, probably for the time being our palaeontological wealth is very limited for besides what has been mentioned it can only be increased by certain gasteropods in calcareous soils, diatom banks, and human or natural kitchen middens, some relatively old. This is true, especially as regards the human remains but all are essential for the study of the climatic and ecologic evolution of the Quaternary.

These successive alternations of climates and sea levels have contributed particularly towards the constant change of the local topography, of which man, represented by his primitive races, has been witness. Man has seen our rivers flowing more than 30 metres above their present beds, carrying waters to diluvial floods; he has seen the sea covering the Polana; the escarpment of Magude forming rocky shores a few metres above the "General Carmona" bridge; the same with the Mangulans quarries; or even reach the first counterforts of the Lebombos and he may also have seen the sea very much further away from the present shores.

Certain unevennesses of the soil are indicative of the fluctuations of the coast-line. The Changane river, very salty, was previously probably a series of lagoons close to the sea formed by the development of the counter-dunes; as this process can be seen clearly to-day from Vila de Joao Belo to Inharrime. Some lagoons are old arms, and others (even far in the interior) have been estuaries of rivers which have not yet been completely filled with deposits. Among those which can be included, there are lagoon E' Fucué near the junction of the Limpopo river and the river dos Elefantes, and specially lake Chuali, at the junction of Mazimehopes and the Incomati.

In many of the deposits, described on the surface or in the interior, there are found implements purposely constructed, which not rarely suffered also the changes those deposits went through and are recognised by their finish, polish or patina and which determine to-day archaeological stations of varied cultures, in a very complete range, from the most ancient to the most recent.

All these peculiarities, geological or archaeological are a consequence of various intermittent factors and of the length of time for which these deposits have been subjected to numerous and various influences. In the life of a man these events seem static, yet they may decide the future of a Race.

It is particularly its wealth of geological facts that the Colony of Mozambique can best contribute to the solution of some of the problems of South African Prehistory. A very interesting chapter in the study of the correlation between Geology and Prehistory is thus opened.

The interdependence of the two sciences of Geology and Prehistory is once more confirmed, as already ably indicated by the late Dr. Alex. du Toit, in his statement that "*Climatic fluctuations form the true background of African Prehistory.*"

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EDUCATION, SCIENCE AND CULTURE IN THE BUILDING OF THE WORLD OF TO-MORROW. FEAR AND PARANOIA AS IMPEDIMENTS TO PROGRESS.

BY

DR. ANTONIO BARRADAS.

Presidential Address to Section F of the South African Association for the Advancement of Science. Read June 30th, 1948.

When I look at the list of the names of my predecessors in this office :— Prof. A. G. Hooper, Dr. F. E. T. Krause, Dr. E. G. Malherbe, Dr. William Russell, Prof. I. D. MacCrone, S. B. Asher, J. D. Rheinallt Jones, etc. etc.—I am fully aware of the great distinction which the executive of the South African Association for the Advancement of Science has conferred upon me, and I wish to express my sincere thanks and my great appreciation of the honour.

I see before me citizens of the Union and citizens of Mozambique most of whom are members of sister institutions and of the Association and to whom I have been appointed to deliver a presidential address at the close of a year of cultural work in History, Sociology, Pedagogy, etc., and I therefore wish to put before you some views and conclusions on Education, Science and Culture which in a scientific age must be based on fact, and other views on Fear and Paranoia which may influence civilization and form obstacles to Progress.

My thesis will be: *Is or is not Mankind passing through a crisis*? It would seem so. Is it a crisis of conscience, of religious sentiment?, of world economy?, of intelligence?, of Government authority?, or is it not rather a crisis of the soul, that is to say, is it the "ego" of man that is in crisis?

We speak much of the *ego* when we refer to the individual man, and hardly at all when speaking about an inherent principle in the mass of men whose thoughts, feelings and whatever is in crisis develop into a total panic of thought, intelligence and of the life of affection or sensitivity, influencing the will and, therefore, the life of action.

If we appeal to Education, to Science and Culture, we may perhaps find a remedy or alleviation for the crisis which is reigning at the present historic moment.

This is the thesis which I propose to elaborate and defend and for which I am bold enough to request your kind consideration, whether you be on the right or left side of this Presidential Chair on which I will be seated for a short while.

I hope that my appeal to the facts of Education, Science and Culture may unite the suffrages even of Fascists, Democrats and Communists, who in this respect could be of one accord.

Education :— By Education we may understand the modification and elaboration of instinct by personal or imparted experiences, leading the individual to modify thought or action.

Educability, already existing in some primates, is carried to high levels in man by the use of *symbols*, and particularly, by the use of *words*. And now, almost universally by *drawing* and *writing*.

The extension of education to the whole of adult life in every class has hardly begun yet.

"Whilst Education is only dawning in the world, it is being forced upon everyone by that rapid increase in the range, complexity, and instability of social co-operation which is the fundamental characteristic of contemporary experience", says H. G. Wells. The need of extending education, created by the new economic life, has been plainly realized. Reading and writing conduce to the penetration of general ideas—that is, the value of work, wealth and happiness to mankind, as well to thorough comprehension of the general lines of human progress. Besides Reading, Writing and Counting the fundamental education of the past, we must now teach Biology, Economics and veracious history.

History gives a knowledge of Social Life ; Biology facilitates the knowledge of Hygiene and Medical Science; studies on Economy teach us the importance and meaning of Work and Leisure, of Poverty and Wealth, of Conflict and Understanding among peoples and races. The connection of these three subjects provides a deep vision of life, and a philosophy showing why we must tolerate trouble and sacrifice.

In creating a philosophy, we might almost say a religion is created. Confucius, the founder of a doctrine, seems almost the founder of a religion. Religion comes from *re-ligare*, which means "to join again" and has always been a new associative arrangement for humanity. For the masses, religion is always necessary for a proper comprehension of life and right conduct.

A movement may be noted all over the world which has in it much of a religious character, that is, it has a spiritualist tendency, differing, however, from any other religion in that it has not a great name as founder, being inspired only by great thinkers. In this movement there is the element *re-ligare*, for it aims to join in it all countries and all races. It further lacks the characteristic of a religion for it is not based on dogma.

It does not combat any religion for it has as followers men of all races and religions. This movement deifies neither Science nor Reason but it involves the necessity of making Education, Science and Culture preside over the World's affairs.

I invite all members of Section F. of the S.A. Association for the Advancement of Science to join in this movement. It is almost unnecessary to say this, as I feel sure you have all done so.

In the study of national History there must be a substitution of the deification of the war heroes by a just appreciation of the heroes of labour.

In Geography great importance must be given to Human Geography and in this the distribution of local and acquired wealth among various countries and nations.

With regard to numbers, it must be noted that there are 440 million children of school age and that for the education of these children 440 thousand schools would be necessary if we rated the distribution at 1000 per school.

Care should also be taken in the way in which education of the masses should be effected—in reference to both children and adults.

Education is nothing more than the preparation of man for a life of collaboration, and by the education of adults through books, newspapers, films and radio we can still correct much of what misinformation and misunderstanding has done in the past.

The great increase of means of communication in recent decades has resulted in education being no longer mainly occupied with the local panorama but finding ample opportunity for observing and comparing the educational policies of other nations and their results.

Facing the final aims of education and school and considering the means they dispose of, we see that we must consider, apart from pupil and teacher, the locality, the environment and the organization.

If the primary aim of education is to give the pupil a vision of the world, in his aspiration for peace and happiness, we must give him a general and thorough education in particular specialities in order that he may be able to live in Society, by Society and for Society.

I may be told that Education and Science are already well spread all over the world, that there are many schools and many scientific institutions. I do not contest that, but I will ask whether the Education so widely spread is satisfactory in quantity and quality. I ask whether the sums contributed by Governments to the advancement of Science are on a level with those destined for other activities, whether they are not more restricted, more grudged than those given for other activities. I ask whether, in the medical field, for example, the medical man who practices the art of healing has not greater financial encouragement than the man who, in a laboratory, carries out researches for the discovery of a cure for cancer or how to fight leprosy.

Research Institutes in the world should have every financial support from Governments. The time for scientific research by an individual has passed, and such scientific discoveries are rare

to-day. The present time needs team work and this is often the only method of work possible. It demands the closest collaboration between research workers, often exacting much devotion and self-denial.

These elements of devotion and of abnegation are absolutely necessary for the processes of civilization. To form men with these qualities it is not enough to have teachers of science in the schools: it is necessary to have masters who possess the scientific spirit. The scientific spirit that should be inculcated by education must awaken in the individual a sense of exactness in his observation and description of phenomena. The conception and realisation of this sense will lead him to make hypotheses. Critical sense and experiments will show him whether any hypothesis is confirmed or not; in the first case, by observation, classification and correlation he will find a law that governs the phenomena.

In children, as in primitive men, thoughts are still dreamlike and fanciful. The thoughts of a child are fed on *fiction*, those of the adolescent on *metaphors* and those of the adult on *logic*. Humanity repeats this evolution summarily and is still in the second stage. This childishness is characteristic of humanity when still uneducated and it makes generalization and abstract ideas difficult.

As soon as a well spread and well directed educational system for children and adults is established it will be possible to commence team work to meet the intense life which civilization demands. Scientific work must not go on at random, it must move side by side with the scientific spirit, that spirit of priesthood which brings devotion and self-denial, and has its own deontology. Empiricism longs for the powers to distinguish matters by thinking and experience, without reason or theory, and it is often successful owing to its practitioners' inflexible determination to survive.

It is the spirit's tendency; the so-called scientific spirit which takes—as Antonio Sergio says—the initiative to question and the initiative to answer.

It does not rely wholly on either induction or deduction, it discriminates, observes, experiments, reflects and finally judges. To-day's education aims to be scientific and not empiric. It is necessary that those who have a vocation for scientific investigation be directed and given the indispensable working conditions and collaborators who will themselves eventually recruit disciples and successors. It is essential that they acquire a thorough understanding of their social position and of the part Science must play in the elevation of the lives of the masses.

Culture:—I now propose to say a few words about Culture.

Culture means not only the simple fact of acquiring knowledge but an attitude towards the scientific or artistic aspects of life.

We must in no way confuse culture with education as is frequently done. There are many educated men who have little or no culture.

In the life of Educated Nations whose existence we anticipate, the guidance of the world must be entrusted to educated men with a scientific and cultured mind, which is without doubt, the solid foundation of complete character.

There is to-day an Institution which undertakes to enlighten and inform governments on educational, scientific and cultural points of view, I refer of course to UNESCO.

The UNESCO'S programme demonstrates that international co-operation in Education, Science and Art may neutralize the causes of war.

We may impress the masses with this basic idea by means of the press, radio, and cinema, the best tools for propaganda to-day, and the first step is to press for prohibition with penalisation against all direct or indirect war propaganda, just as against other crimes. Another organisation, the B.I.E. of Geneva has similar views and objects and both bodies are collaborating upon a basic programme of Reconstruction, Communication, Education, Cultural interchange, Human and Social Relations, and Natural Sciences. Or, more in detail:— 1. World-wide attack on illiteracy, 2. Revision of text-books, 3. Development of mass communication, and removal of barriers, 4. Research on the conditions of life in the tropics, 5. Attack on malnutrition, 6. Study of tensions conducive to war, 7. Common ground to understanding, by examination of the philosophic problems of the time, 8. International exchange of persons, 9. Freedom of creative artist, 10. International inter-library, Assistance to libraries, museums and art galleries, and public libraries.

Summing up: The UNESCO intends to promote an international agreement in the field of Education, with a view to extending the mental horizons of all people by means of common plans and institutions.

In the preliminary sessions, in Paris, the president of the American Delegation, Mr. William Benton, said that the combined budgets of all nations for their military and naval establishments is at least ten thousand times the size of any budget contemplated for UNESCO.

Another American Delegate said that all over the world men's spirits and bodies are sickened and their thoughts divided and made antagonistic, in turn by fear, ambition or resentment.

Civilization:—By Civilization we understand the growth of the material and mental standards of thought and conduct through the successive ages of Stone, Bronze, Iron, etc.

The inheritance of material assets and the practice of such mental activities as determine or result from a high standard of collective life, is what, in everyday language, is meant by *Civilization*. One of its characteristics is the continuous development, or *Progress*, which must take place within a definite order.

From social disorder a retrogression of Civilization may result.

The patrimony of material assets of man has been improved and enriched by the successive acquisition of fire, the wheel, animal traction, navigation, steam, explosion motor, aviation, electricity, lightning arrester, telegraph, atomic energy, television.

The progress of mental activities is stimulated by imagination and thought, limited by the conservative mind and arrested by fear ; the refinement of the mind is no longer an endowment of Civilization but of Culture, which is only attained when thought is disciplined into becoming critical and reflective.

Civilization can be imposed : Culture asserts itself: it is the refinement of all mental forces.

Civilization and Culture establish and assert themselves after the elimination of fear, and it can be said that the most civilized man—and also the happiest—will be he who is free from the fear of anyone or anything. Primitive man lived in fear of all things, of elements (fire, water, land and space), of trees, of animals and of other men.

Humanity is still living in great ignorance as H. G. Wells puts it, and because of that its actions are still made at random, and by conjecture, as in the Middle Ages ; this is the case even in the highest form of human action, namely, that of governing itself. In these times of cultural and scientific enterprise one must act according to a plan.

It is only after recovering from Great Wars, Plagues, Disease, and Famine that mankind could consider the necessity of ending their senseless quarrels and collecting and preserving their knowledge, considering also how not to crush but to regain their natural powers.

The three centuries from the beginning of the eleventh to the end of the 15th were an age of recession for Western Europe, and it was only as the 15th century drew to its close that any indication of the real vitality of Western Europe and of a certain resemblance to the present state of affairs becomes apparent. During the phase of apparent retrocession an accumulation of mental and physical energy continued and broke out very impressively at its close.

In the middle ages the fundamental lines of a new harder and more efficient type of human community were being laid down. That type of community—The Modern State—is still in its formative phase in spite of all attempts to combine two apparently contradictory ideas, the idea of *community of faith and obedience*, and the idea of *community of will.* It was, then that freedom of conscience and intelligence began to make its appearance.

The broad antagonism between the method of obedience and the method of will runs through history down to our times and to this day their reconciliation is incomplete.

Something restless and untamed in our race has striven continually to extend civilization from its original preference for a governing section which exacts unparticipating obedience from

the entire community, and to endow the nation with enlightenment and the rights of self-government. This natural and temperamental struggle of mankind to reconcile civilization with freedom has been kept alive, age after age, but hitherto the government of States has either remained authoritative or has become largely an uneducated and uninformed democracy which degenerates into a mere rule by mob and politicians.

The modern ideal is a world-wide educational government in which the ordinary man is not the slave, but rather an informed, inspired and consulted part of the community.

Fear :— Primitive man cast his eyes upon the earth on which he walked or upon the sea ; looked at other beings who lived with him—his fellow creatures or the other animals—raised his eyes to the firmament when it opened with downpours of water or violent hailstorms, heard the winds contending together, saw the flash of lightning when it tore the blackness of the sky, looked at the moon and the stars and, in the dawn of thought, began to feel fear.

He feared the darkness of the night, the tempest, the earthquake and the waves, the comets and eclipses and feared the end of the world. Finally he feared hunger which stalked him, the disease that decimated him, the war that his fellow waged against him and which he, through fear, at times provoked.

At the same time, as he began to be conscious of his manhood —Eheu ! Eheu ! (I am, I am)—as Eca says in "Adam and Eve in Paradise"—he began to feel himself a target of persecution by enemies, by wild beasts, by Divine wrath in the form of plagues. In the boldness of youth, his incipient personality reacts in opposite forms ; either by flight, by withdrawing into himself, or by fighting and turning into a persecutor.

The aspects in which we may regard fear may be physical, physiological, geographical, historical, economic and social.

Franklin Roosevelt proclaimed the liberation of man from the four fears that confound and humiliate him : viz.—1. Fear of need. 2. Fear of illness, 3. Fear of war, 4. Fear of tyranny.

It is in the conquest of liberty or the liberation from the four fears that the great scope of Civilization resides.

The physician has to free man from the diseases that destroy him, but only the psychiatrist can achieve the freedom of man from his fears. Medical men, especially psychiatrists, will have to teach us to recognise paranoiacs, on which subject I must say a few words.

Paranoia :—This mental anomaly with systematized delusions takes the form of ideas of persecution and, simultaneously, ideas of grandeur and ambition, with a tendency to mysticism and credulity.

There is almost always a certain aloofness from reality, combined, as the case may be, with timidity and suspicion or with vanity and pride.

It may be said that the fundamental emotions of vanity or pride and of fear and suspicion are the groundwork of the disease.

Although, generally speaking, paranoiacs manifest marked intellectual clearness and a certain amount of determination of character, their mental constitution is particularly subject to emotional disturbances without the power of correcting them by the appeal to reality.

In the persecutory paranoiacs the patient refers to his persecutors as "they" or as "society" or some other corporate body such as lawyers, priests or freemasons.

In ambitious paranoia many of the patients affect to be descendants of historical personages; the sphere of religion affords an endless field for the ambitious paranoiacs and some of them may even aspire to divine, or almost divine authority.

In a not uncommon form of paranoia—ambitious and persecutory—the subject believes that he is a man of unbounded wealth and power, the rights to which he is, however, deprived by the machinations of his enemies. Often he is persistent and threatening in his determination to obtain redress for his imagined wrongs. Some paranoiacs are not troublesome, but calm, dignified, self-possessed and reserved on the subject of their delusions.

The true paranoiac is, however, a person of anomalous mental constitution and he can always be capable of committing a crime.

They never analyse themselves but only the exterior world of which they believe themselves to be the centre. Their self-sufficiency takes the delusions of their minds as unquestionable and certain.

The paranoiac is immovable and irreducible: he is the negation of the learned and of the philosopher.

He is highly clever and often exuberantly active, colouring the conceptions of his delirious mind in such way that he often has the power of dragging the crowds after him.

It is said that liberty ends when it begins to eliminate the liberty of others. From this point on it ceases to be liberty and becomes licence. But this applies to the normal man. By the light of his self-centred ideas and hypertrophy of his inner self the paranoiac sees only what he considers to be his own rights. He does not defend Right and Justice—he defends *his rights* and *his justice*.

It is a social danger when the paranoiac is endowed with the high office of leader, whatever may be the name by which such directorship is called: Leader, in English; Führer in German, or any other word in any other language.

There will come a day when some psychiatrist of genius will give us a study on the psychosis of the masses.

The instincts of the primitive man—to steal, to kill, to make war, to dominate and impose slavery on others—have not yet quite disappeared from mankind.

The Christian spirit seemed to have destroyed such instincts. However, we can see that though silenced or softened they were not completely destroyed, for they will awaken even in the normal man under the call of violent passions such as love or hate.

In the abnormal man—paranoiac or moral madman—these instincts remain active, especially so when the social environment is under a crisis—low moral or low culture. In the double delirium —grandeur and persecution—no doubt about the truth of the subject he fights for disturbs the paranoiac.

Will the paranoiac win his fight? Let us see. He is extremely *distrustful* and exaggeratedly *ambitious*. In social life, in the fight for living, the normal distrustful man may win when he knows how to conduct his aspirations.

But not so the paranoiac. He is a weakling and seems strong only in certain spheres corrupted by fear and cowardice ; he will succumb in the fight as soon as those spheres awaken to the reality of their own worth and to the paranoiac's delirious delusions. The absence of critical sense in all relations between his own self and his environment—nature and society—leads the paranoiac to his own destruction.

Civilization tends to restrain man's impulses, his fears, his fights, his slavery. These impulses exist in the souls of children, savages, and in the paranoiac. In the first two they are overcome by education and colonization but there is no such liberation for the paranoiac, Society must remove him from its own life.

As there is no way of treating this mental anomaly except by segregating the patient, the sooner this is done the better. His restraint will not only be a benefit to society but to himself.

I believe I have given you, in a brief outline, an idea of what I think of the role Education, Science and Culture will play in the building of the world of to-morrow, and also of the importance of fear and paranoia as impediments to civilization and progress.

I know that the exposition of my thesis seems somewhat fragmentary and disjointed. I have certainly not been able to prove my theme fully ; rather than prove it I have taken to heart to propose it, to expound it to your intelligence and your souls and leave you the task of finding the solution.

I feel sure that if we concentrate on work of such magnitude, we shall have contributed, more than in any other way, to the realization of the universal understanding on which peace depends.

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SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLV*, *pp.* 88-94, *March*, 1949.

THE PENETRATION, FIXATION AND AVAILABILITY OF PHOSPHATE IN LOWVELD SOILS.

BY

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Read before Section C of the South African Association for the Advancement of Science, 28th June, 1948.

South Africa spends annually £3,000,000 on the purchase of phosphatic fertilizers. In general our soils throughout the country are very low in both total and available phosphate, and thus considerable quantities of phosphate must be applied to all cultivated soils if agricultural production is to be maintained at a reasonably high level. The rapid rise in land values makes it necessary for every farmer to obtain as high a yield as possible from a given area of land. Bear and Toth (1942) have indicated that the recovery of applied phosphate in the crop that is planted immediately after its application amounts to from 10 to 30 per cent of the quantity added to the soil.

This low percentage recovery of phosphate has been studied in this preliminary investigation from three aspects.

1. PENETRATION OF SOLUBLE PHOSPHATE INTO SOILS.

Many workers have shown that the loss of applied phosphate in drainage water from soils other than sand is negligible. In order to obtain some idea of the penetration of super-phosphate in an acid granite soil, each of the 4 replications of the O and P fertilized plots from the Main Citrus Experiment at the Subtropical Horticultural Research Station, Nelspruit, was sampled in April 1948, at depths of 0-3", 3"-6", 6"-12" and 12"-24".

Differential fertilizer treatment in this experiment was started in 1939. All the P plots received 640 lbs. superphosphate per acre per annum. The phosphate was applied in mid-November of each year just prior to the planting of Sunn-hemp which has been consistently used as the green manure crop, and on maturity is disked into the soil. The total phosphorus was determined in this work by extraction with hydrochloric acid, precipitation as ammonium phosphomolybdate and gravimetric estimation. The available phosphorus was determined in accordance with Rubins' and Dean's method (1946), by extraction with .002N H_2SO_4 and the

phosphorus determined colorimetrically using the Evelyn photo-electric colorimeter.

The following table gives the mean of the results obtained for each treatment as well as the available phosphate on a composite sample from the 4 replicates.

TABLE 1.

PENETRATION OF PHOSPHATE INTO SOILS.

	Control Plots.		Phosphate Plots.	
Depth	Total % P	% Av. P.	Total % P.	% Av. P.
0-3″	.0064	.00004	.0145	.00047
3-6″	.0052	.00003	.0129	.00035
6-12″	.0037	.000027	.0058	.00020
12-24″	.0051	.000027	.0067	.00006

The difference between the P fertilized plots and the control decreases with increase in depth indicates that even in a coarse sandy soil under conditions of high summer rainfall coupled with regular winter irrigation, the downward movement of phosphate is of a comparatively small order.

2. FIXATION OF PHOSPHATE IN SOILS.

The work of Davis (1943), Bear and Toth (1942), (1947), and others on the relative phosphate fixing capacity of soils appeared to offer a profitable line of approach to the problem. The method for the determination of the phosphate fixing capacity of soils proposed by these workers was modified and carried out as follows :—

Three samples of 25 gm. of each soil under investigation were weighed out. On one sample the hydrochloric acid soluble phosphate was directly determined. The other two samples were transferred to erlenmeyers and to each, 150 ml. of solutions containing 150 mgm. and 450 mgm. respectively of P as mono-calcium phosphate was added. The erlenmeyers were shaken several times daily for a period of 5 days. Thereafter the contents were carefully transferred to a Buchner funnel and all soluble phosphates washed out of the soil with distilled water. The soil from the Buchner was then transferred to a large beaker and the mass extracted as for the untreated soil. Phosphate determinations were made on suitable aliquots from all the extracts. The difference between the amount of phosphorus in mgms. in the phosphated and the untreated soil gave the amount of phosphate fixed from each solution. The following results were obtained :—

TABLE 2.

FIXATION OF PHOSPHORUS IN SOILS.

No.	Soil From	Type	Depth	Approx.	Mgm. P. in 25 grams Soil, soluble in HCL	Mgm. P. in 25 grams Soil, after treatment with 150 ml. with 150 mgm. P. in solution	Mgm. P. in 25 grams Soil, after treatment with 150 ml. with 450mgm. P. in solution
1	Karino	Granite sandy loam	0-12″	1·7	1·8	3·3	4·5
2	Karino	Granite sandy loam	0-12″	6·3	2·0	3·8	3·0
3	Alkmaar	Granite sandy loam	0-12″	5·5	1·5	3·0	5·9
4	Nelspruit	Granite sandy loam	0-12″	5·0	1·6	10·7	9·6
5	Nelspruit	Granite sandy loam	12-24″	5·2	1·7	22·3	22·3
6	Nelspruit	Granite sandy loam	24-48″	6·0	2·2	21·6	23·7
7	Alkmaar	Red Brown Loam	0-12″	6·1	2·0	18·6	28·0
8	Alkmaar	Red loam	12-24″	5·6	1·9	32·4	39·0
9	Alkmaar	Red loam	24-60″	5·5	1·0	26·0	30·4
10	Louws-Creek	Brown loam	0-12″	5·0	1·3	23·7	33·3
11	Louws-Creek	Brown loam	0-12″	5·0	1·4	16·6	20·6
12	Malelane	Red Brown loam	0-12″	7·0	2·3	31·1	16·1
13	Malelane	Dark red brownloam	12-30″	6·0	1·1	30·7	42·7
14	Malelane	Red loam	30-57″	7·0	1·0	64·2	64·5
15	Malelane	Red loam	57-72″	7·1	0·8	93·9	104·5
16	Malelane	Red loam	72-96″	7·3	1·4	87·1	109·3
17	Schoemans-kloof	Gray heavy loam	0-12″	6·0	2·0	56·8	69·1
18	Graskop	Red brown loam	0-12″	4·5	1·3	105·5	92·6
19	Graskop	Red brown loam	12-24″	4·2	1·6	82·7	93·9

DISCUSSION OF RESULTS.

All the soils in Table 2 are soils that have been intensively cultivated and fertilized for a number of years.

The data obtained from these soils are relative only, as the figures are largely dependent on the soil to soluble phosphate ratio, but they have great value for comparative purposes. Soil No. 1 fixed the lowest amount of phosphate, i.e. 1.5 and 2.7 mgm. respectively from each of the solutions, whereas Soil No. 18 fixed the highest amount, i.e. 104.2 and 91.3 mgms. respectively from each of the solutions. If the amount of phosphate fixed from each solution is expressed as a percentage of the total amount of phosphate added it will be seen that the percentage fixation is always higher in the 150 mgm. P solution, indicating that there was a sufficiency of phosphate in this solution to saturate the soil fixing mechanism, and results of greater practical value might have been obtained had lower concentrations of phosphate solution been used.

It is at once apparent from the figures presented in Table 2 that there exists a wide variation in the capacity of different soil types to fix phosphate. On the basis of an acre 6 ins. of soil weighing 2,000,000 lbs. soil No.'s 1 and 18 should be capable of fixing the the approximate equivalent of 0·6 and 41 tons of 20% superphosphate. Bear and Toth (1942) quote fixations as high as 125 tons of 20% superphosphate equivalent per acre 6 ins. Under field conditions, despite the lack of intimate contact of soil and phosphate as obtained by thorough mixing of the soil and phosphate in the pots higher fixation should theoretically be obtained as the ratio of soil to phosphate is of a much higher order.

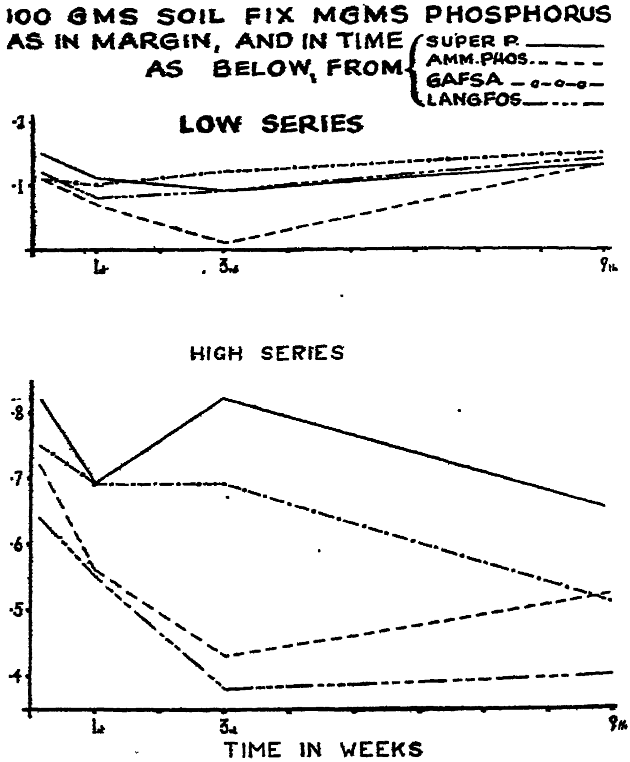
It appears from the results given in Table II that no general phosphatic fertilizer recommendation would suffice to cover efficiently, a range of soil types differing so widely in their capacity to fix phosphate.

In soils having a low fixing capacity, water soluble phosphates such as superphosphate are obviously excellent to use. The phosphate should be applied around the plants and the application should immediately be followed by a good irrigation unless 1-2 inches of rain have fallen. Soil No. 4 obtained from the Nelspruit Research Station has a comparatively low fixing capacity for phosphate. In the light of practical observations over the last few years it is evident that this fixation capacity is high enough to justify placement of phosphatic fertilizer. Retief (1946) working on maize and the writer (1948) on tomatoes have shown that placement unavailability of phosphates plays an important part in our soils, i.e. far better results are obtained by the spread along the row method of application as compared with broadcasting or topdressing. In the Malelane area the writer (1948) while investigating "Blue Disease" of tomatoes caused by a deficiency of available phosphate in the soil found it possible to increase the yield of tomatoes by 1,000 boxes per morgen, by applying superphosphate in the row at planting time as compared with topdressing.

Under conditions of high fixation it is essentail that phosphatic fertilizer be applied in the row as near as possible to the root system of the plants.

3. Different Forms of Phosphate and Their Availability in Granite Soil.

The relative availability of superphosphate, ammonium phosphate, Gafsa (imported Tunisian rock phosphate having 10 per cent citric soluble and 24 per cent total P_2O_5) and Langfos (South African rock phosphate—7 per cent citric soluble and 17 per cent total P_2O_5) was studied in pots. Sandy loam of granitic origin, typical of the Nelspruit area was used in this experiment.



Milligrams of Phosphorus fixed by 100 grams soil, from various phosphates in various periods of time.

The soil was carefully air dried and passed through a 2 mm. mesh screen. After being thoroughly mixed over a period of days, 15 Kgm. of soil was weighed into each pot. Phosphatic fertilizer was given to each pot at a rate equivalent to 20 lbs. for the low series and 100 lbs. P for the high series per acre 6 ins. (2,000,000 lbs). Fertilizers were applied by spreading the soil on a canvas square and thoroughly mixing soil and phosphate. Sufficient water was

then added to bring the moisture content of the soil up to approximately 60 per cent of its total water holding capacity. After periods of 1 day, 1 week, 3 weeks and 9 weeks respectively the contents of the pots were emptied onto canvas, the soil thoroughly mixed, and a representative sample withdrawn for analysis, and the soil returned to the pots. The moisture content of the pots was maintained at between 40-60 per cent of the total water holding capacity.

A control treatment to which no phosphate was added was included in the experiment. 4 replications of each treatment were used, and the pots laid out as a randomised block experiment. By subtracting the mean value obtained for available phosphate at each sampling date from the mean of the treated pots the availability due to the phosphate added was approximately determined. These figures have been set out in the preceding 2 graphs for the low and high phosphate series respectively.

In the low series the availability of superphosphate drops rather rapidly down to the third week, and then rises slowly. From the end of the 1st week the availability of phosphates from Gafsa and Langfos rises gradually and at the end of the ninth week is slightly greater than from superphosphate. Under the conditions of this experiment the performance of ammonium phosphate has been disappointing. This may be accounted for by the fact that the extractant was $\frac{N}{500}$ H_2SO_4-.

In the high series the availability of the phosphate in superphosphate has proved superior to all the rest. It is assumed that in this case the phosphate fixing capacity of the soil has been saturated leaving a substantial balance of the superphosphate added in a readily available form.

The Gafsa rock phosphate under the conditions of this experiment was superior to both Ammonium phosphate and Langfos. The high level of Langfos has given disappointing results. It is possible that the free lime content of this fertiliser has been sufficient to neutralise the acid extractant. These laboratory results are being followed up by plant tests in both pot and field trials.

SUMMARY.

1. The Writer in preliminary investigations found that the penetration of both total and available phosphate in a sandy soil of granitic origin decreased with increasing depth. Superphosphate had been applied over a period of 9 years.

2. The phosphate fixing capacities of a series of soils from the Eastern Transvaal Lowveld were determined. Some of the types investigated fixed amounts equivalent to .6 ton and others varying up to 41 tons of 20 per cent superphosphate per acre 6 ins.

3. The relative availability of P in two water soluble phosphates and two rock phosphates was determined in pots. Soil (pH5) and respective phosphates were thoroughly mixed and packed into pots and the soil moisture maintained at 40-60 per cent of the total water holding capacity of the soil. Samples for analysis were

withdrawn after 1 day, 1 week, 3 weeks and 9 weeks respectively. Where low quantities of phosphate were applied the rock phosphates proved slightly superior to the soluble phosphates. In the high series the order of superiority was as follows—Superphosphate, Gafsa, Ammonium Phosphate, and Langfos. These laboratory results are being followed up by plant tests in pots and in the field.

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SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLV*, *p.* 95, *March*, 1949.

PROBLEMS ON SOIL MAPPING; A REAL CASE.

BY

ARIO L. AZEVEDO AND DOMINGOS H. G. GOUVEIA

Read before Section C of the South African Association for the Advancement of Science, July, 1948.

SUMMARY.

After some discussion of soil maps and a rapid critical survey of the works published dealing with African soils cartography, the authors call attention to certain concrete problems of soil mapping.

During the soil survey of Provincia do Niassa a case was found, the Metarica Catena, that supports their opinions.

It is a catenary complex (topographical and lithologic) and the complete succession of its full development is as follows:

Grey skeletal soils are found on the steepest slopes of mountains and near the base of 'inselbergs'; red soils on ridges with good drainage conditions; orange soils on steep slopes of fairly good drainage; orangelike soils on intermediate zones almost level; grey over yellow soils, of sluggish drainage on the fringe of bottom lands and grey or grey-black soils on bottom lands ('dambos') with "gley" horizons.

The iron concretions and ferruginous hardpans are frequent at variable depths: very deep at the highest points and near the surface or exposed at the bottom lands.

The soil texture is sandy when the soil is formed upon parent material derived from a granite very poor in ferro-magnesian elements, and clayey when derived from a granite very rich in the same elements.

The dominant vegetation of red soils is *Brachystegia-Isoberlinea* woodland; the woodland's stand decreases as the soils vary from red to yellow and, at same time, other genera appear and even dominate as for instance *Uapaca*. On the fringe of bottom lands a different type of vegetation occurs, including *Terminalia*, and finally the 'dambos' with their characteristic associations.

The technique of mapping this catena will be exactly the same as used by Milne.

The authors emphasize the advantages of collaboration between soil scientists of different countries and the mutual help of botanists, geologists and pedologists in fulfilling their aims.

The authors express their thanks for the kind assistance of Geoffrey Milne and Prof. J. V. Botelho da Costa.

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLV*, *pp.* 96-97, *March*, 1949.

CYTO-GENETICS IN RELATION TO BREEDING PROBLEMS OF CARICA PAPAYA, L.

BY

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Read before Section C of the South African Association for the Advancement of Science on Tuesday, 29th June, 1948.

ABSTRACT.

Due to the fact that the papaya is cross-pollinated it is practically impossible to maintain the purity of a variety unless special precautions are taken. This may be achieved, however, by hand pollination, which can be mastered easily by any grower. A single cross-pollinated fruit will yield 1,000-2,000 seeds and a few such fruit will produce sufficient seed for the new planting. The incorporation of purple stem, yellow flower and pink fruit flesh in new varieties in order to distinguish them from ordinary commercial plantings which generally have non-purple stems white flowers and yellow fruit flesh will assist to distinguish new varieties and to detect impurities resulting from outcrossing. The use of sex-linked seedling characteristics is suggested as an aid to detect seedlings for sex before transplanting, since experiments have proved that there is no direct method to distinguish between the sexes before flowering time. Cyto-genetic studies have indicated the possibility that the sex ratio may be controlled so that from 66% to 100% of the progeny of certain crosses would be composed of female or fruitbearing trees. This would mean a considerable saving of plant material since the grower is usually forced to plant 3-4 plants per hill to allow the weeding out of surplus males. The experiments with respect to the cyto-genetic control of the sex-ratio are of a specialized technical nature and further studies are necessary before the results can be applied on a commercial scale.

SUMMARY.

1. Papaya growers are advised to practise hand-pollination since this is the only practical way to maintain the purity of a variety.

2. The incorporation of known qualitative characteristics like Y, yellow, y, white flower colour ; P purple, p, non-purple stem colour and R, yellow, or pink fruit flesh, with specific varieties will be helpful to detect impurities which might result by outcrossing.

3. There is no direct way to detect the sex of seedlings. Sex-linked seedling characteristics, however, could be used, indirectly, for this purpose.

4. Male and female plants are genotypically respectively M_1m and mm. Crosses of 3n x 2n plants should yield trisomics of the M_1mm genotype. Random pairing of sex chromosomes should yield a ratio of $1M_1m : 2mm$ in the progeny of the cross mm x M_1mm if n+1 male gametes do not function, as would be expected. Genetical and cytological studies, however, suggest that M_1m will produce probably only m functional gametes in this cross, resulting in 100% female plants in the progeny. If this is realized it would be of considerable economic importance.

South African Journal of Science, *Vol. XLV*, *p.* 98, *March*, 1949.

INHERITANCE OF DWARFNESS IN CARICA PAPAYA, L.

BY

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Read before Section C of the South African Association for the Advancement of Science on Tuesday, 29th June, 1948.

ABSTRACT.

A dwarf type of papaya has been found which is characterized by profuse branching, whereas normal plants are single stemmed. This difference in growing habit is probably due to a difference in the production of growth hormones or auxins, in dwarf and normal plants, being higher in the latter than in the former. Hence heritable factors or genes may control growth by determining the production of growth hormones. Although the dwarf papaya is of no commercial value it could be planted under certain conditions where space is a limiting factor, as for instance in the back yard.

Summary.

1. An extension of our knowledge of the genetics of the papaya is necessary since it is needed, especially for cytogenetic studies which may be helpful for the solution of practical breeding problems.

2. The inheritance of a dwarf(d) type of papaya is reported. It is recessive to normal (D).

3. Dwarf plants are characterized by a bushy habit, whereas comparatively little branching is evident in normal plants. This difference in growing habit is probably related to a difference in auxin production.

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLV, p.* 99, *March,* 1949.

ON THE IMPORTANCE OF THE LEGUMINOSAE IN MOZAMBIQUE.

BY

J. GOMES PEDRO, ENG. AGR.(C.I.C.A.)

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d before Section C of the South African Association for the Advancement of Science on Friday, 2nd July, 1948.

SUMMARY.

The Author traces in outline the distribution of the main types of the vegetation where certain genera and species of the Leguminosae group of families play an important role physionomically, phyto-geographically and ecologically.

The Author also gives some examples of correlation between types of climate and types of soil on the one hand, and important or peculiar genera and species of the group of families mentioned on the other hand.

As an introduction to the Leguminosae flora of Mozambique a provisional list is given; it includes about 110 genera and 760 species that have been recorded either in literature or in herbaria.

The Author wishes to express his full acknowledgements to the South African systematists and ecologists who have helped him in his task, and his special thanks are offered to Dr. R. A. Dyer and to Professor John Phillips of the Witwatersrand University.

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLV*,
pp. 100-105, *March*, 1949.

A COMPARISON OF FOUR NITROGENOUS FERTILISERS ON VELD.

BY

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Read before Section C of the South African Association for the Advancement of Science on Monday, 28th June, 1948.

Introduction.

Previous experiments by the Agricultural Advisory Section having shown (1, 2) that nitrogen gives a marked response on South African pastures, it was decided to compare several types of nitrogenous fertilisers on veld at Frankenwald, the Botanical Research Station of the University of the Witwatersrand.

Methods.

A one-morgen camp was selected with a sward which appeared to be uniform. This camp had not been fertilised since experiments were started on this station in the 1932-33 season. Eighty-four plots were marked out, each 7 yards by 10 yards, with 3-foot paths in each direction between plots.

Examination of the plots after they were marked out showed that fourteen were not suitable for the purposes of this experiment, being located on outcrops of rock or having a vegetative cover which differed widely from that on the rest of the camp. On the remaining seventy plots, fourteen treatments were distributed at random in five blocks. The following were the treatments :—

O	N/SPK
P	N/APK
S/AP	UrPK
N/SP	S/A_2P
N/AP	N/S_2P
UrP	N/A_2P
S/APK	Ur_2P

P=400 lb. Rock and superphosphate mixture per morgen.
(W.S. P_2O_5 7.3%, C.S. P_2O_5 11.8%, total P_2O_5 21.3%)

S/A=600 lb. Sulphate of ammonia per morgen per annum in three dressings. (Low nitrogen treatment).

N/S=Nitrate of soda,

N/A=Nitrate of ammonia, and

Ur=Urea, all at the same rate of nitrogen application per morgen. (Sulphate of ammonia= 21.1%N, Nitrate of soda= 15.5% N, Nitrate of ammonia=32.5% and Urea=46% N).

K=80 lb. KCL (60% K_2O) per morgen.

S/A_2=1200 lb. Sulphate of ammonia per morgen per annum in three dressings. (High nitrogen treatment).

N/S_2, N/A_2 and Ur_2 at the same rate of application of nitrogen per morgen as in the case of S/A_2.

In the 1944-45 season the first nitrogen applications were given on the 8th December, 1944, but it was not possible to give the three dressings of nitrogen as planned and only two applications were given. In the two following seasons the first cutting was taken before any fertilisers were applied, and as the seasons were unfavourable owing to late rains, only two dressings of nitrogen were given in the 1945-46 and 1946-47 seasons. Three dressings were given as planned in the 1947-48 season.

Botanical Composition.

It was hoped to complete a botanical survey of the experiment with at least five quarter-meter quadrats on each plot, but owing to wartime shortage of staff, it was only found possible to complete thirty quadrats on the five no-fertiliser plots and one other plot.

The general average of these thirty quadrats gave the following botanical composition :—

Digitaria tricholaenoides	4.21 %
Tristachya hispida	4.27 %
Heteropogon contortus	4.94 %
Eragrostis chalcantha	3.29 %
Harpechloa falx	2.16 %
Digitaria monodactyla	1.62 %
Elyonurus argenteus	1.56 %
Trachypogon plumosus	1.49 %
Microchloa caffra	1.07 %
Other grasses	2.69 %
Herbs and weeds	.83 %
Bare ground	71.87 %

Soil Reaction.

Before any fertilisers were applied, five soil samples were taken at random in each plot with a soil auger. The samples were taken at depths of 0-4 inches and 4-8 inches. The pH was later determined by means of a Cambridge potentiometer with a glass electrode. The average results for all plots were :—

0-4"	5.58	Range 5.12—5.96
4-8"	5.54	Range 5.08—5.88

Results.

The plots were mown, usually when the grasses were in full leaf, by means of an ox-drawn mower in the first two seasons and with a small tractor mower in the two subsequent seasons. Three cuttings were obtained in each season, including one before the application of fertilisers in the first season.

After mowing, the grass was allowed to dry on the plots and was then raked up by hand. The herbage from each plot was

places in bags and weighed on a counter scale with a large pan. Subsequently a sample was taken from each plot to give fourteen composite samples which were sent to the Umbogintwini Factory for moisture and nitrogen determinations.

DRY MATTER YIELDS.

Table 1 gives the average yields of five plots in each treatment over the four year period.

TABLE 1.—DRY MATTER PRODUCTION ON VELD.
Annual Yields in lb. per morgen.

Treatment.	1944-45*	1945-46.	1946-47.	1947-48.	Average.
O	974	2190	2587	2343	2024
P	1236	2618	2681	2379	2229
S/AP	1639	3973	3613	5554	3695
N/SP	1519	3466	3948	4808	3435
N/AP	1326	3374	3895	4863	3365
UrP	1319	3265	3699	4677	3240
S/APK	1615	3563	3798	5314	3573
N/SPK	1696	3414	3244	4619	3243
N/APK	1439	3665	3423	4294	3205
UrPK	1440	3236	3349	4242	3067
S/A_2P	1885	4593	5148	7269	4724
N/S_2P	2177	4303	4274	5092	3962
N/A_2P	1691	4249	4215	5016	3793
Ur_2P	1617	3563	3819	5073	3518
Seasonal Rainfall	28.97	25.21	24.49	32.42	

*Two cuts only after fertlisers applied.

Table 2 gives the return of dry matter obtained per pound of nitrogen applied after subtracting the yield obtained in the phosphate only treatment in each season.

TABLE 2.—DRY MATTER RETURNS.
Pounds Dry Matter per pound of Nitrogen.

Treatment.	1944-45.	1945-46.	1946-47.	1947-48.	4 Season Average.
S/AP	4·8	16·1	11·1	25·2	14·3
N/SP	3·3	10·1	15·1	19·2	11·9
N/AP	1·0	9·0	14·4	19·7	11·0
UrP	1·0	7·7	12·1	18·2	9·8
S/APK	4·5	11·2	13·3	23·3	13·1
N/SPK	5·4	9·4	6·7	17·7	9·8
N/APK	2·4	12·4	8·8	15·2	9·7
UrPK	2·4	7·3	7·9	14·7	8·1
S/A_2P	3·8	11·7	14·6	19·4	12·4
N/S_2P	5·6	10·3	9·4	10·7	9·0
N/A_2P	2·7	9·7	9·1	10·4	8·0
Ur_2P	2·2	5·6	6·7	10·7	6·3

NITROGEN RETURNS.

The yields of nitrogen in the herbage for the first three seasons are given in the following table :—

TABLE 3.—NITROGEN UPTAKE IN VELD PASTURE.

Annual Yields of Nitrogen in lb. per morgen.

Treatment.	1944-45.	1945-46.	1946-47.	Average.
O	8·2	20·1	23·7	17·3
P	10·9	23·9	23·0	19·3
S/AP	13·9	37·6	32·3	27·9
N/SP	13·7	31·6	37·0	27·4
N/AP	12·1	32·8	36·5	27·1
UrP	12·2	34·1	35·5	27·3
S/APK	15.6	34.7	36.8	29.0
N/SPK	16.4	33.2	30.6	26.7
N/APK	13.0	35.8	34.3	27.7
UrPK	14.5	30.4	32.9	25.9
S/A2P	20.2	48.9	50.7	39.9
N/S2P	22.0	43.1	40.6	35.2
N/A2P	16.2	46.7	41.8	34.9
Ur2P	14.0	35.5	36.7	28.7

The percentage recoveries of nitrogen after subtracting the nitrogen yield of the O or P treatments, whichever is the greater, are given in Table 4.

TABLE 4.—PERCENTAGE NITROGEN RECOVERIES ON VELD PASTURES

Treatment.	1944-45.	1945-46.	1946-47.	Average.
	% Recovery of Nitrogen			
S/AP	3.6	16.3	10.2	10.0
N/SP	3.3	9.2	15.8	9.4
N/AP	1.4	10.6	15.2	9.1
UrP	1.5	12.1	14.1	9.2
S/APK	5.6	12.8	15.6	11.3
N/SPK	6.5	11.1	8.2	8.6
N/APK	2.5	14.1	12.6	9.7
UrPK	4.2	7.7	10.9	7.6
S/A2P	5.5	14.8	16.0	12.1
N/S2P	6.6	11.4	10.0	9.3
N/A2P	3.1	13.5	10.7	9.1
Ur2P	1.8	6.9	7.7	5.5

DISCUSSION.

In the first three seasons, the distribution of the rainfall during the season was not as favourable as the seasonal totals indicate and hence total yields and recoveries of nitrogen were lower than might have been expected. Nevertheless, the yields for the most part show an upward trend over the four seasons; this seems to indicate that the veld will make its highest response to fertiliser treatments after two or possibly three years of treatment.

As far as yields of dry matter are concerned, sulphate of ammonia has given better results than the other three forms of nitrogen. Total yields have been greater and the three sulphate of ammonia returns in pounds of dry matter per pound of nitrogen applied have been the highest.

In comparing the two groups based on the low application of nitrogen, it would appear that the addition of potash has tended to decrease the returns.

Nitrogen uptake by the herbage and the percentage recoveries for the first three years of the experiment were low. The highest single recovery found was given by the S/AP application in the season and the highest average return by the double sulphate of ammonia treatment.

There have been no marked changes in the botanical composition on any treatments as yet, nor is there any evidence that the soil reaction has been affected by the treatments to any extent. The experiment is, however, being continued and possibly changes will become evident in due course.

Summary.

This paper describes a comparison of four nitrogenous fertilisers on hitherto unfertilised veld at two rates, namely, 600 lb. and 1200 lb. sulphate of ammonia per morgen in three dressings. The other three fertilisers—nitrate of soda, nitrate of ammonia, and urea—were applied at equivalent rates of nitrogen application.

For the first three seasons only two dressings of nitrogen were given instead of three as originally planned, i.e. 84.4 lb. nitrogen per morgen instead of 126.6 lb. and 168.8 lb. instead of 253.2 lb.

Three cuttings of hay were obtained in each season. The yields in the first season were low and subsequently showed a tendency to increase each year. As an average of the four seasons, the no-fertiliser treatment gave 2024 lb. dry matter per morgen, and 400 lb. rock and superphosphate mixture per morgen once in the four years, 2229 lb.

The low application of nitrogen in the form of sulphate of ammonia with phosphate gave an average yield of 3695 lb. and this treatment plus potash, 3573 lb. The high nitrogen application as sulphate of ammonia plus phosphate gave 4724 lb.

The average yields given by the other three nitrogenous fertilisers were in all cases inferior to those given by sulphate of ammonia.

The dry matter returns per pound of nitrogen applied also rose fairly consistently over the four-year period. The highest return was given by the low sulphate of ammonia application plus phosphate in the 1947-48 season, namely 25.2 lb. This treatment also gave the highest four-year average return of 14.3 lb.

The uptake of nitrogen in terms of pounds per morgen and the percentage recoveries of nitrogen have been low. The highest yield of nitrogen per morgen in the herbage was 50.7 lb. in the double sulphate of ammonia treatment in the 1946-47 season. 16.3% was the highest recovery obtained in any treatment and the highest average returns were given by sulphate of ammonia.

Acknowledgements.—The authors wish to express their thanks to the laboratory staff at the Umbogintwini Factory for the analyses of herbage samples, and to Mr. S. Murray who supervised the experiment during the 1945-46 and 1946-47 seasons. Thanks are also due to Messrs A. R. Hughes, R. J. Fretwell, C. T. Carter and E. J. Seagrief, for assistance with the botanical survey.

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SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLV*, *p.* 106, *March*, 1949.

A NOTE ON SOME HUMAN SKULLS FROM LOUISVALE NEAR UPINGTON.

BY

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Read before Section D of the South African Association for the Advancement of Science, 28 *June*, 1948.

ABSTRACT.

The MacGregor Museum, Kimberley, possesses four skulls exhumed at Louisvale, eight miles from Upington. One of these skulls is almost purely Bushman in type, two are predominantly Bushman with an intrusive long-faced element, the fourth belongs to a wholly contrasted type with a much longer, low-vaulted, and ovoid braincase and a very large flat face. This last compares better with "Hottentot" skulls described by Dreyer and Meiring from Kakamas than with those described by Broom from Upington; it also resembles skulls from other localities identified by Broom as "Korana". It is held that all these skulls represent a mixture of at least two main elements. One of these is a large-headed Bushmanoid strain descended from the Middle Stone Age types of South Africa, the other a "Europide" strain allied to prehistoric types from East Africa. In the Louisvale skull IV the former of these types predominates, while the latter is probably responsible for the long-faced element in skulls II and III and for comparable types identified by Dart in living Bushmen. It is maintained that there is no single physical type which can be called "Hottentot",; Broom's use of the name "Korana" for a physical type is also rejected. The name "Douglas type" is suggested for skulls in which the large-headed Bushmanoid strain predominates, and "Kakamas type" for those which are predominantly "Europide".

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THE METHODS AND AIMS OF TAXONOMIC STUDY IN ENTOMOLOGY, WITH SPECIAL REFERENCE TO LEPIDOPTERA.

BY

Dr. A. J. T. Janse.

Read before Section D of the South African Association for the Advancement of Science in July, 1948.

Apart from the study of plants, the study of insects is possibly the most popular with people who have the essential qualities of a naturalist. Perhaps the immense variety of forms and colours is responsible for this ; or it may be the comparatively easy way in which insects can be preserved in their natural condition and appearance, and yet the scientific study of insects in this country is more neglected than that of any other group of animals, considering the vast number of insects we have and their importance in nature.

The Economic Importance of Insects.

It is a curious fact that the important role of insects in nature and in human life and the great connection there is between insects and the rest of the organic world only began to be realised about a century ago. The study of insects revealed that without them there would be no flowering plants, except a few pollinated by birds and the winds, that without insects many birds, most reptiles and amphibia and some fishes and some mammals would disappear, that without insects a number of diseases in animals and plants would also disappear, while without some insects our crops of food would in many instances be greater. In short, it was realised that insects are responsible for large losses in food and in human life, and this resulted in the development of economic entomology, a science which has during the past fifty years reached such important dimensions in almost every civilised country. Insects are conceived to be "pests" to human beings and as such should be studied with a view to their destruction, so as to make the life of man easier and safer.

But with the rise of economic entomology the study of insects from a purely academic point of view was pushed more and more into the background until in turn it was gradually realised that the academic study of insects was also essential to the economic entomologist.

The Study of Taxonomic Entomology.

Taxonomic entomology deals with the insect's anatomy and biology from the point of view of showing the relationships between species and groups of species and thus aims at a *natural* classification. Up to the middle of last century classification of the smaller groups,

such as families, genera and particularly species, was based on *superficial* characters which, in the higher groups, such as Orders, gave on the whole a natural grouping even before it was realised that plant- and animal-life had actually developed from lower forms and that classification should therefore express *natural* relationships, particularly between species, genera and families.

A great advance was made when the importance of wing-venation was discovered by Herrich-Schaeffer between 1843 and 1856 and the results were applied by Meyrick, to a more natural classification, keeping in view Darwin's theory of organic evolution. Later Comstock and Needham, by studying the ontogenetic development of wing-venation, threw much light on the phylogenetic development of the higher groups and their natural relations.

Of greater importance, however, was the discovery made during the latter part of last century, that in most groups of insects the reproductive organs throw even more light on the relations between species and groups of a higher order than characters used earlier and there is no doubt that the time will come when more advantage will be taken of these organs in taxonomic work. One has already come to the conclusion that in many insect-orders the study of these organs is absolutely essential for a correct identification of the species, an unquestionable fixing of the name and, I am convinced, also for the defining of genera.

THE IMPORTANCE OF CORRECT NAMING.

The fixing of the name, apart from the purely, scientific aspect, is essential to the work of the economic entomologist, since the name gives him access to the literature of the subject. It often enables him to take measures against a "pest-insect" before the damage reaches too great dimensions. If the life-history of a related species has already been worked out, it may even enable the entomologist to attack a "pest-species" before its life-history is fully known. The correct name of the pest-insect tells him whether it is indigenous to the country, or whence and how it was introduced, to what plant it is naturally attached, etc., and he can then take measures accordingly. In short, to know the *correct* name may mean immediate attack and sometimes quick results; to get the *wrong* name may lead to serious mistakes, with consequent delay in combating the enemy.

All this is fully realised by the economic entomologist, even though he is seldom a taxonomist. He is, as a rule, fully occupied with the study of the living insect and the methods of control or eradication, the taxonomist on the other hand mainly deals with the dead material after it has been suitably preserved. From this it is clear that taxonomic entomology is principally the function of museums, as is the case with other classes of animals. Allow me to give you a bird's-eye view of what taxonomic research in insects involves and what difficulties present themselves, especially in a new country like South Africa. In doing this I will deal chiefly with the study of Lepidoptera as I have studied this Order most

intensively for the past forty years ; but much of what I have to say applies to most other Orders as well.

THE DIFFICULTIES ENCOUNTERED.

The first point I have to draw your attention to is the vast number of species one has to deal with when specialising in some Orders, such as Hymenoptera, Diptera, Coleoptera, Hemiptera or Lepidoptera. These five groups together contain well over 443 thousand described species out of the nearly half a million species named up to the present time. Of these the Coleoptera with nearly 200,000 species take the lead, followed by the Lepidoptera with almost 100,000 described species.

These figures, of course, include insects from all over the world and it is almost impossible for one institution to deal with even one of these Orders on a world scale, so most institutions confine themselves to a larger or smaller region such as the Palaearctic, American, Indo-Australian or African regions ; others again are content, or compelled, to restrict themselves to much smaller areas with political boundaries.

It is here that the first difficulty of the taxonomist arises, for, when he has a sufficiently wide knowledge of the subject, he finds that even between two large regions there is no well defined boundary as far as genera, and in some groups even species, are concerned. This becomes particularly difficult when a family contains a large number of widespread genera or a genus has many species. A newly found *Crambid* may be one of the 500 described in that genus already, and some genera are even larger. Thus *Eucosma* has nearly 800 species described in it !

In order to know whether a species is already described or not, one has to have as complete a knowledge as possible of the literature concerning the group one specialises in and make this knowledge readily available by means of a card-index system. The amount of labour this involves will be realised when I mention that for one family alone (the Pyralidae) I had to make well over 30,000 entries and for the remainder of the Micro-lepidoptera I had to compile an index system of over 100,000 cards, each of which has the name, reference to the literature, locality and, where required, the synonomy of the species. But in order to find the name of the species or genus, or determine it as undescribed still more is needed than this. In addition the descriptions have to be systematised, unless one has already a comprehensive collection of named material, properly arranged, well preserved and correctly identified. If such a collection is not available one has to make "keys", so as to have the descriptions in tabular form.

This is not always easy to do from the actual specimens, but to do it from the descriptions is a difficult and laborious task, where there are many genera and species as there are in an almost unexplored country like South Africa. Generic "keys" should really contain all the genera described in that family from all over the world, for according to our present state of knowledge, there are

many genera that know no faunistic boundary. To add to this difficulty many genera were defined fifty and even a hundred years ago and none of the characters considered at present important are mentioned in the old descriptions while some of the descriptions of those days are untrustworthy through lack of the proper methods or the proper instruments. For that reason a study of the specimen of the species on which the genus is based I now consider essential for thorough modern taxonomic work and for the last thirty years I have collected such material from all over the world. Above all, such genotype material is particularly required for the study of the genitalia of the group because this line of research is so comparatively recent that it has been neglected in studying most of the older species and genera.

THE IMPORTANCE OF THE STUDY OF GENITALIA.

The study of these structures is very important in most insect-orders. I often wonder how far botanical classification would have advanced had not these genital organs been the main consideration in building up a natural arrangement. Yet this is precisely what has happened in entomology and even now it is mainly used for the defining of the species, while I am now convinced that the organs are often of great use for the defining of genera. In Lepidoptera the genitalia of both sexes are certainly more constant than the wing-markings on which, formerly the species was almost entirely based and I have come to the conclusion that no specific description is complete, *nor should it be recognised as valid*, unless these structures have been dealt with, at least those of the male. As it is often difficult to describe those structures without an illustration, so as to give a clear picture of the details to other workers, it seems advisable to insist on a figure as well. Such ruling would have many advantages of which the following may be specially mentioned :—

1. The structure of the genitalia fixes the concept of species more definitely and is less variable than any other character hitherto used.

2. The proper study of the genitalia requires a technique that takes time and practice to acquire and does not readily come within the scope of the superficial "species-maker" who merely describes a new species for unscientific reasons.

3. Insisting on a figure may also retard the "species-manufacturing" process but on the other hand gives a readier means of making use of the information published.

4. Genitalia, when properly prepared on a slide, are more durable than the dried specimens used for description as prepared in the ordinary way and will consequently be longer available for future workers. It is an almost permanent record of the species as it was at the time of description and will thus present comparison material for the study of the development of species over periods of hundreds of years even after, perhaps, the original specimen, or type, has been lost or destroyed by museum pests.

THE IMPORTANCE OF INSECT TAXONOMY TO THE STUDY OF EVOLUTION AND LAND CONNECTIONS.

After having this bird's-eye view of the scope, methods and difficulties of taxonomic study in entomology, the question readily arises :—what is the scientific value of this type of research, apart from supplying a name of an insect-pest to the economic entomologist.

Naturally, it is difficult to assess the value of any academic study until use can be made of it by mankind. Most research at its earliest stage was thought to be rather valueless or at best an interesting luxury and it may appear to many that the taxonomic study of insects is still in that doubtful stage except for those insects, or groups of insects, that have proved to be of economic importance.

There was a time when this was thought of the study of mosquitoes and the study of termites, flies, fleas, lice or ticks. In these cases however the taxonomic study has already proved of great value to the health of both animals and men, and to know all there is to be known about these creatures is most important. And so, I feel sure, it will be in almost every insect-order in time to come.

But apart from that, such study is of the greatest value in forming a more complete picture of organic evolution and its underlying principles. Insects multiply so rapidly, occur in such vast numbers and respond so readily to environmental conditions that they form excellent material for the study of the laws and methods of evolution. The question which is answered by some people in the negative, namely :—are new species still evolved to-day? can best be settled by the taxonomic study of insects. Descriptions, illustrations, material of the adult insect itself and especially their preparations preserved for several hundreds of years, should give us information on evolution which no slow-breeding animal can provide. Hence the importance of collecting, studying and preserving what our insect-fauna offers to-day.

This study will also provide information about changes a country undergoes under the influences of climate and cultivation, for most insects are closely associated with, or even dependent on, the original flora of a country. If this flora changes in order to make room for the cultivation of foodplants, through overstocking and desiccation, the insect fauna will change as well. Some insects will adapt themselves and consequently change in appearance or structure, others will disappear and thus connecting links may be lost. No doubt many insects will always remain, including a large number harmful to man, but the original fauna will to a large extent disappear or be changed.

The distribution of genera, once these are properly defined, may throw light on former land-connections supposed to have existed in remote geological times between countries now far apart. Some authors are already convinced on this evidence that South Africa was at one time connected with India, South America and possibly Australia. However I think these conclusions are at

present rather premature, seeing that most of the genera are insufficiently studied and that of many only a few species are known; but I am convinced that along these lines the study of geographical distribution will illucidate problems that cannot be solved otherwise. In how far the Wegener drift theory will be substantiated by the study of South African and South American insects is still to be seen, but I am sure that when sufficient material has been collected and studied taxonomically *along modern lines* the results may be of inestimable value.

THE URGENCY OF THE MATTER.

But a new country, like South Africa is still insufficiently explored, as regards the insect fauna and, in view of the rapidly changing conditions on account of encroaching cultivation, no time should be lost in collecting and studying what there is at present still left before important links have been exterminated. A great deal is said and written about the possible disappearance of the larger animals; game reserves are set aside by the Nation and appreciated by the public, but the insects of that area are hardly known; no systematic survey has yet been made of them and the original insect-fauna may in the near future be largely exterminated before we ever knew that it was there! It is the duty and function of museums and similar institutions to preserve as much as possible of this South African fauna and flora before it disappears and the insect fauna is the most neglected and yet the richest of them all. It is the duty of the taxonomist to study and describe what material is still available and pass on his results to future generations.

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A BENZENE HEXACHLORIDE-RESISTANT TICK.

BY

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Read before Section D of the South African Association for the Advancement of Science on Tuesday, 29th June, 1948.

ABSTRACT.

In previous papers it has been shown that 50 p.p.m. *gamma* isomer of benzene hexachloride gave complete control of the arsenic-resistant blue tick, *Boophilus decoloratus* Koch, in *in vitro* experimental work. Benzene hexachloride dips when used at this concentration of the gamma isomer in dipping tanks, and where weekly dippings were followed, have given satisfactory control of this tick in the field, and have indeed safeguarded the cattle industry of the Eastern Cape and Natal.

Recently however, some eighteen months after their first use on certain farms in the East London district, benzene hexachloride dips appeared to be losing effectiveness against the single host blue tick. Adult female ticks were collected from cattle on the farms concerned and were subjected to *in vitro* tests in various benzene hexachloride preparations, as were ticks taken from cattle in the Albany and Bathurst districts.

These experiments showed that the ticks from the East London district reacted very differently to ticks from the Albany and Bathurst districts, when subjected to the same gamma benzene hexachloride treatments. Thus approximations of 50 p.p.m. gamma isomer gave 100% control of Albany and Bathurst ticks, and even 25 p.p.m. had a marked effect on them. These concentrations of the gamma isomer gave little control of ticks from the East London district, which seemed to be able to tolerate high concentrations, as even 179 p.p.m. had little effect upon them.

The experiments indicated that a benzene hexachloride-resistant strain of the single host blue tick, which is also resistant to arsenic, had developed in the East London district of South Africa.

The present distribution seems to be limited to small areas on the East and West Banks of the Buffalo River. It is remarkable that this new strain of tick has appeared in the same locality as the arsenic-resistant strain first appeared some ten years ago. It is

also disquieting that this development should have happened so soon after the use of benzene hexachloride dips in the field. A further potential danger thus exists for cattle farmers in areas where the arsenic-resistant tick has been so successfully controlled by benzene hexachloride dips.

The full text of this paper will appear in the *Bulletin of Entomological Research.*

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SOME PRELIMINARY OBSERVATIONS ON THE CONTROL OF THE BONT TICK *AMBLYOMMA HEBRAEUM* KOCH.

BY
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Read before Section D of the South African Association for the Advancement of Science on Tuesday, 29th June, 1948.

ABSTRACT.

For the past three years benzene hexachloride dips have been successfully used against the single host arsenic-resistant blue tick, *Boophilus decoloratus* Koch. The use of these dips against the two and three host ticks, where control measures have to be directed mainly against the adult stage, has not been fully investigated. This paper presents a preliminary study of the control of the three host Bont Tick, *Amblyomma hebraeum* Koch, with benzene hexachloride and arsenical dips and a combination of these. The benzene hexachloride dip used was a dispersible paste.

The experiments were carried out from February to May, 1948, and weekly counts of adult male and female bont ticks were made on treated and untreated animals prior to each weekly treatment. At the farm "Paardekraal", all 20 experimental animals grazed in the same camp. Thus the results of the insecticidal treatments, as reflected by the tick counts made on the four groups of five animals each, could be compared. These results are presented in the table below, and in addition, dipping and spraying methods of application are compared.

"PAARDEKRAAL".

TOTALS OF 15 WEEKLY COUNTS.

Untreated			0.16% As_2O_3 Spray	
Males	15,613	20,133	6,598	11,167
Females	4,520		4,569	
BHC Dip wash 50 p.p.m. gamma isomer			**BHC Spray 50 p.p.m. gamma isomer**	
Males	3,709	7,335	2,941	4,836
Females	3,626		1,895	

The figures showed that all treatments greatly reduced the male bont tick population on the cattle, and clearly illustrated the relative effectiveness of the various treatments on female bont ticks.

On each of three other farms, "Langholm Estates" (2 dipping tanks), "Willowfountain" and "Tharfield", 10 experimental cattle were distinctively marked. Five cattle were dipped each week and five were left undipped as control animals. The effects of benzene hexachloride and arsenical dip washes and combinations of these on the bont tick populations, are shown in the table below.

"Langholm Estates" Tank 2 Totals of 13 Weekly counts		'Langholm Estates" Tank 1 Totals of 7 Weekly counts	
Untreated	100 p.p.m. gamma isomer	Untreated	50 p.p.m. gamma isomer + 0·16% $As_2 O_3$
Males 2,132 Females 447 } 2,795	209 101 } 310	Males 613 Females 144 } 757	259 190 } 449
"Willowfountain" Totals of 15 Weekly counts		"Tharfield" Totals of 10 Weekly counts	
Untreated	50 p.p.m. gamma isomer	Untreated	0.16% $As_2 O_3$
Males 3,055 Females 822 } 3,877	762 587 } 1,349	Males 3,293 Females 1,186 } 4,479	1,375 1,177 } ,552

From these experiments it appeared that all treatments markedly reduced the numbers of male bont ticks on the cattle. The two arsenical treatments did not reduce the numbers of female bont ticks, nor did the composite wash containing 0.16% $As_2 O_3$ and 50 p.p.m. of the gamma isomer of benzene hexachloride. The two tanks containing only 50 p.p.m. of the gamma isomer appeared to have given slightly better results against the female bont tick than the above treatments. Striking results against the female were obtained by spraying cattle with freshly diluted wash containing 50 p.p.m. gamma isomer, but dipping cattle in 100 p.p.m. of the gamma isomer also gave satisfactory results.

From these preliminary observations it would appear that further investigations are necessary to determine the relative merits of arsenic and benzene hexachloride as measures for controlling the bont tick.

The full text of this paper will appear in the *Bulletin of Entomological Research.*

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SKEDELMORFOLOGIE EN -KINESE VAN *TYPHLOPS DELALANDII* (SCHLEGEL).

DEUR

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Met 11 *Figure.*

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Inleiding

Die *Typhlopidae* en die *Leptotyphlopidae* word gewoonlik as die primitiefste lewende verteenwoordigers van die slange beskou. Beide families is volkome aangepas aan 'n fossoriale leefwyse en leef in sagte sanderige grond.

Dumeril en Bibron (1854) groepeer die twee families saam onder die *Opoterodonta*. Boulenger (1893) beskou die *Typhlopidae* as die primitiefste slange, maar Mahendra (1938) meen dat die *Leptotyphlopidae* die primitiefste is en dat ander slangfamilies van akkedisvoorvaders, verwant aan *Leptotyphlopidae*, afgelei moet word.

Die familie *Typhlopidae* bestaan uitsluitlik uit die genus *Typhlops* wat omtrent 125 species omvat.

Die oudste beskrywing van 'n Typhlopsskedel is dié van Müller (1838). In 1882 gee Peters 'n beskrywing van die skedel van *Typhlops dinga* onder die naam *Onychocephalus* dinga. Lakjer (1926) gee hoofsaaklik 'n beskrywing van die kouspiere, en hierdie werk vorm die uitgangspunt van dié van Haas (1930) oor die kouspiere, skedelbewegings en skedelmorfologie van *Typhlops punctatus*.

Die species *Typhlops delalandii* is die eerste keer deur Schlegel in 1844 onder die naam *Typhlops lalandii* beskryf. In 1893 het Boulenger die naam verander na *Typhlops delalandii*.

Typhlops delalandii kom oor die hele suidelike Afrika voor en het 'n gemiddelde liggaamslengte van 30 cm. In sy werk „Snakes of of South Africa" (1919) gee Fitzsimons 'n beskrywing van die uitwendige kenmerke van die Suid-Afrikaanse *Typhlopidae*.

Die doel van hierdie navorsing is bloot om 'n beskrywing van die skedelmorfologie te gee, en beoog geen filogenetiese gevolgtrekkings nie.

Materiaal en Tegniek.

'n Volwasse en 'n jeugdige eksemplaar is vir hierdie ondersoeking gemikrotomeer. Ontkalking: drie weke lank in Ebner se oplossing; na ontsuring in 5% Na_2SO_4 oplossing; is die materiaal deur die alkohole tot by 70%-oplossing geneem en toe in Grenacher

se borakskarmyn in 'n termostaat by 40 °C. geverf. As kontraverfstof is 'n 33%-oplossing van azaan (Grübler) gebruik. Grafiese rekonstruksies is met behulp van die „Panphot"-projeksie-apparaat, mikrometerscala en geruite-papier gemaak.

EIE ONDERSOEKINGS

Neuskapsel.

Die cartilago cupolaris is voor, mediaan volledig en geen aparte foramen apicale is te onderskei nie, omdat laasgenoemde ingelyf is by die fenestra narina. Net voordat die cartilago cupolaris by die septum nasi aansluit, word dit deurbreek deur 'n groot foramen mediale nasi vir deurlating van 'n tak van die ramus lateralis nasi V (fig. 1).

Die voorste gedeelte van die tectum nasi is volledig maar na agtertoe is die kraakbenige dak onderbroke.

Die sygedeelte van die cartilago cupolaris word onderbreek deur 'n groot fenestra narina vir die uitwendige neusgang of vestibulum. Die gedeelte van die cartilago cupolaris wat die onderste grens van genoemde fenestra vorm, dra 'n lang uitsteeksel die processus alaris inferior (fig. 2). By *Typhlops delalandii* is geen processus alaris superior te onderskei nie, tensy die dorsale wand van die fenestra as sodanige beskou moet word. Peyer (1912) en Brock (1929) beskryf albei uitsteeksels by *Vipera aspis* en *Leptodeira hotamboia* onderskeidelik. Bäckström (1931) kon albei uitsteeksels by die jonger embrios van *Tropidonotus natrix* aantoon, maar by die ouer embrios verdwyn die processus alaris superior geleidelik.

Die tectum nasi word onderbreek deur 'n groot fenestra dorsalis nasi wat ooreenstem met die fenestra olfactoria en fissura orbitonasalis soos deur Gaupp (1900) by *Lacerta* beskryf.

By *Typhlops delalandii* is geen fenestrae superiores, soos by *Lacerta* aanwesig nie, ook kon Brock en Peyer (op. cit.) dit by *Leptodeira hotamboia* en *Vipera aspis* nie aantoon nie ; in hierdie opsig stem slange volgens Brock met krokodille en skilpaaie ooreen. By 'n *Crocodilusembrio* kon Brock ook geen sodanige fenestra aantoon nie. Dieselfde toestand heers ook by baie akkedisse soos die *Geckonidae*, *Agamidae*, *Iguanidae*, ens.

Peyer (op. cit.) beskryf 'n onvolledige fenestra lateralis by *Vipera aspis*. By *Typhlops delalandii* is dit afwesig, en by *Leptodeira hotamboia* kon Brock (1929) dit ook nie aantoon nie. By *Tropidonotus natrix* is dit egter aanwesig (Bäckström, op. cit.), hierdie outeur weerspreek Rice (1920) se stelling wat beweer dat die fenestra lateralis nasi van *Lacerta* niks anders as 'n onvolledige verkraakbeningsgebied is nie. Aangesien genoemde fenestra by *Tropidonotus natrix* baie laat ontstaan, kan dit volgens Bäckström nie met bogenoemde gebied ooreenstem nie, en hy voer as rede aan die toestand by *Sphenodon* waar die fenestra lateralis ook eers by baie later stadia ontstaan.

Die agterste gedeelte van die septum nasi ontstaan uit die versmelting van die twee trabeculae in die neuswyk. Heel voor, daar waar die septum by die cartilagines cupolares aansluit, is dit breed ; na agtertoe word dit egter smaller en kom baie meer dorsaal te lê : net onder die dalende gedeeltes van die frontalia.

Brock (1929) kon by *Leptodeira hotamboia* geen crista septi wat die septomaxillare stut aantoon nie. By *Typhlops delalandii* is dit ook afwesig, en die septum vertoon in 'n dwarssnit eenvoudig as 'n vertikaalstaande plaat.

Die lamina orbitonasalis eindig heeltemal vry na agter, daar is geen verbinding met die septum nasi nie (fig. 1 and 2). By *Leptodeira hotamboia* (Brock 1929) is die lamina orbitonasalis agter in verbinding met die septum deur middel van 'n kraakbeenstaf. In eersgenoemde geval is die toestand dus soos by meeste ander reptiele waar die lamina orbitonasalis los is van die septum. Brock (1929) meen dat die versmelting 'n sekundêre toestand kan wees, 'n aanpassing wat in verband staan met die tengerige geaardheid van die skedel in die neuswyk. Verder sluit sy die moontlikheid dat dit 'n primêre toestand is nie uit nie, want die versmelting by alle stadia van *Leptodeira hotamboia,* en verder die vroeë optrede en later reduksie by *Vipera aspis* (Peyer, op. cit.) wys daarop dat dit die primêre toestand kan voorstel. Gaupp (op. cit.) beskou die nie-versmelting as primêr omdat die septum by akkedisse los is van die lamina orbitonasalis en versmelt is by gespesialiseerde diere soos soogdiere. As gelet word op die aparte ontstaan van die neuskapsel van die trabeculae dan moet die versmelting as die sekundêre toestand beskou word.

Die solum nasi by *Typhlops delalandii* is heeltemal onvolledig en word slegs verteenwoordig deur die lamina transversalis anterior wat die orgaan van Jacobson ventraal stut (fig 1 en 2). Na agter word die lamina transversalis anterior voortgesit as die cartilago ectochoanalis, wat net agter die lamina orbitonasalis eindig. Die lamina transversalis is heeltemal los van die sywand van die neuskapsel en van die cartilago cupolaris : hier bestaan alleen 'n baie losse bindweefselverbinding met die septum nasi. Hierdie toestand varieer blykbaar by slange onderling, want in die ontogenie van *Tropidonotus natrix* is dié gedeelte van die lamina transversalis anterior wat 'n gedeelte van die kapsel van die orgaan van Jacobson vorm, verbind met die sywand en die cartilago cupolaris (Bäckström, op. cit.). Volgens Bäckström stem die toestand by *Tropidonotus natrix* dus ooreen met dié by *Lacerta* waar die kapsel van die orgaan van Jacobson met die zona annularis verbind is. By *Vipera aspis* (Peyer, op. cit.) is die kapsel van die orgaan deur middel van bindweefsel aan die sywand en die septum geheg. By *Leptodeira hotamboia* kon Brock (1929) geen synchondrose aantoon nie.

Peyer, Brock, Bäckström (op. cit.) beskryf by *Vipera aspis, Leptodeira hotamboia* en *Tropidonotus natrix* 'n kraakbeenstrook wat lateraal en parallel met die cartilago ectochoanalis verloop

en daarmee versmelt. Peyer noem dit die hypochoanaalkraakbeen, en Brock en Bäckström meen dat die „sabreshaped cartilages" van *Python tigris*, soos deur Solger beskryf, homoloog is met die hypochoanaalkraakbeen. Born (1883) beskryf twee kraakbeenspange wat by onderskeidelik „ki" en „ke" noem, en de Beer (1937) meen dat dit die processus maxillaris posterior van *Lacerta* voorstel. By *Typhlops delalandii* is geen sodanige kraakbeenstrook aanwesig nie, daar kom wel 'n kraakbeenstruktuur voor wat lateraal van die cartilago ectochoanalis lê (sien „X" fig. 2), maar dit versmelt nie met laasgenoemde nie en verloop ook nie parallel daarmee nie, buitendien versmelt dit met die lamina orbitonasalis. Bogenoemde kraakbeenstrukture is dus nie homoloog nie, en die een wat by *Typhlops delalandii* aanwesig is moet liewers beskou word as 'n deel van die lamina orbitonasalis.

'n Groot processus maxillaris posterior is aanwesig en versmelt met die lamina orbitonasalis (fig. 2) ; ook met betrekking tot hierdie uitsteeksel wys slange variasie, want by *Leptodeira hotamboia* (Brock 1929) is dit afwesig.

Cartilagines paraseptales makeer soos by meeste slange ; Bäckström, (op. cit.) beskryf twee paraseptales anteriores by *Tropidonotus natrix* wat voor met die cartilago cupolaris verbind is, maar egte paraseptales kom nie voor nie.

Die paries nasi is betreklik volledig, dit vorm die concha waarin 'n gedeelte van die glandula nasalis lateralis geleë is. Hierdie concha word volgens Peyer, (op. cit.) gevorm deur 'n induiking van die sywand. Die glandula nasalis lateralis se afvoerbuis gaan deur die fenestra narina in die vestibulum.

Die ramus ethmoidalis Va verloop ventraal van die dalende prosesse van die frontalia, en by die agterkant van die neuskapsel deel dit in 'n ramus lateralis nasi en 'n ramus medialis nasi (fig. 3), en die twee takke verloop dan deur die fenestra olfactoria na vore. Die ramus lateralis nasi gee sover vasgestel kan word vier takke af, wat die neuskapseldak deurboor en die huid innerveer. 'n Foramen epiphaniale soos beskryf deur Bäckström, Brock en Peyer (op. cit.) waardeur 'n tak van die ramus lateralis nasi verloop en die glandula nasalis lateralis voorsien, kon by *Typhlops delalandii* nie nagewys word nie. Die ramus medialis nasi verloop lateraal van die septum na vore en gee takke af wat die praemaxillare deurboor en die huid ventraal innerveer. Die hoofstam verlaat die skedel heel voor deur die fenestra narina.

Orgaan van Jacobson

Die orgaan van Jacobson wat volgens Broman (1919) die belangrikste sinsorgaan by slange is word byna volledig omsluit deur 'n skeletkapsel wat gedeeltelik benig en gedeeltelik kraakbenig is. Die septomaxillare vorm 'n benige koepel rondom die voorste gedeelte van die orgaan. Verder agtertoe word die septomaxillare mediaan onvolledig en lê die regter en linker organe weerskant teen die septum nasi. Dorsaal word die benige dak deurboor deur takke

van die nervus olfactorius (nervus vomero-nasalis) wat die orgaan innerveer (fig. 3). Dit is twyfelagtig of slange 'n werklike nervus terminalis het, behalwe in sover as 'n „nervus terminalis" moet beskou word as 'n ge-emansipeerde ramus van die nervus olfactorius en nie as 'n egte kopsenuwee (dorsale wortel) nie. Die dikwels in leerboeke voorkomende bewering dat die nervus terminalis die spesifieke senuwee vir die orgaan van Jacobson is, geld bepaald nie vir reptiele nie.

Die orgaan self is boontjievormig met 'n induiking aan sy ventrale vlak, hierdie „hilus" word gevul deur 'n digte bindweefselmassa wat ryklik voorsien is van bloedvate. Meer na agtertoe word hierdie ruimte hoofsaaklik deur 'n kraakbeenklont van die lamina transversalis anterior gevul wat saam met die vomer die vloer van die kapsel van die orgaan vorm. Agter die kraakbeenklont stuur die vomer 'n vertikale uitsteeksel in die hilus op. Die voorste gedeelte van die cartilago ectochoanalis vorm 'n ventrale stut vir die recessus ventrolateralis-gedeelte van die afvoergang (fig. 3). Agter mediaan, word die organe regs en links van mekaar geskei deur die vomers wat soos twee vertikaalstaande stawe tussen die organe strek. Die afvoerbuis van elke orgaan gaan deur 'n spleet in die vomer aan sy kant en open dan in die mondholte ; dit word mediaan deur die vomer en lateraal deur die cartilago ectochoanalis gesteun. Die ductus nasolacrimalis open in die mediane wand van die afvoerbuis van die orgaan van Jacobson (fig. 3). Geen verder kliere wat in die orgaan open kon nagewys word nie, en ook nie erektiele weefsel in die wand van die orgaan nie. Broman (op. cit.) kon dit ook nie aantoon nie. Die lumen van die orgaan is spleetvormig en laasgenoemde self bestaan uit 'n vloer en 'n dak, die vloer het 'n slymvlieslaag drie tot vier sellae dik. Sy buitenste laag is effens afgeplat, en die dieperliggende selle het 'n meer silindriese vorm. Die dak is heelwat dikker en is omring met 'n dun bindweefselkapsel, waarvan bindweefselstroke wat die karakteristieke struktuur van die weefsel by slange gee, straalsgewys in die orgaan indring (fig. 3). Net binnekant die kapsel volg 'n dik, kernryke laag met heel binnekant 'n laag silinderepiteelselle met 'n breë gevoelige soom. Volgens Leydig (gesiteer uit Born, 1883) besit sommige selle 'n „nervöse Natur" en kan dus „Ganglienkugeln" voorstel. Born weerspreek hierdie stelling en meen dat die selle aan eenvoudige kliere wat in die hele slymlaag versprei is, behoort.

Die vulling van die orgaan moet op dieselfde manier soos beskryf deur Broman (op. cit.) vir *Lepidosauria* plaasvind, en word veral moontlik gemaak deur die verhouding van die vomers tot die septum nasi. Eersgenoemde staan in losse bindweefselige verbinding met die septum, en enige druk op die monddak veroorsaak 'n druk op die vomer, wat dan die druk op die lamina transversalis anterior oordra. Beide laasgenoemdes oefen dan druk uit op die orgaan sodat die lumen verklein en die vloeistof daarin in die mondholte uitgepers word. Volgens Broman (op. cit.) is die druk van die tong op die monddak miskien selfs genoeg om die lumen te verklein.

As die druk op die monddak afneem vergroot die lumen en suig die orgaan vloeistof uit die mondholte en ductus nasolacrimalis op. Die orgaan sou dan volgens Broman as 'n soort reservoir dien vir die vloeistof wat in die ductus nasolacrimalis vloei. Born (op. cit.) meen dat die vloeistof in die ductus nasolacrimalis vir „einspeichelung" van die buit wat heel ingesluk word dien.

Die orgaan by slange het ook 'n reukfunksie wat deur bemiddeling van die gesplete tong verrig word (Broman, op. cit.).

VERHEMELTE EN NEUSSAKKE.

Die neussakke by *Typhlops delalandii* bestaan uit drie dele soos beskryf deur Fuchs (1908) vir *Tropidonotus natrix*: 'n voorhof of vestibulum, wat vanaf die uitwendige neusopeninge na die „Muschelzone" lei en 'n heelagterste antorbitaalruimte wat deur middel van die choanegang en choane in die mondholte open. In die „Muschelzone" kan 'n „Sakter", „Stammteil" en „Choanengang" (Fuchs, op. cit.) onderskei word. Die grootste gedeelte van die neussakke word deur die neuskapselkraakbeen gesteun. Agter lê die palatinum 'n klein entjie as 'n onvolledige ring oor die choanegang (fig. 4).

Volgens Fuchs moet ons in die monddak van slange, eerstens 'n primitiewe en tweedens 'n sekundêre verhemelte onderskei. Omdat die praemaxillare die hele primitiewe verhemelte beslaan, noem hy laasgenoemde ook praemaxillêre verhemelte. By die volwasse *Typhlops delalandii* is 'n choanepapil (Fuchs) aanwesig wat voor, ventraal, van die „Vomerpolster" en tussen die openinge van die regter en linker organe lê, dus op die grens tussen primitiewe en sekundêre verhemelte.

By *Tropidonotus natrix* tree daar in die ontwikkeling twee lang splete „Choanenspalten" op (Fuchs, op.cit.) wat die mondholte in verbinding stel met die „Muschelzone": dit is die sogenaamde primitiewe choane wat later gedeeltelik toegroei, sodat die orgaan openinge van die sekundêre choane geskei word. By *Typhlops delalandii* kan oorblyfsels van die „Choanenspalten" onderskei word, en die openinge van die organe van Jacobson is in die voorste gedeeltes hiervan geleë. Die twee splete word mediaan van mekaar geskei deur die „Vomerpolster". Agter die openinge van die organe strek twee duidelike „Choanenrinnen" na agtertoe, waar hulle vlakker word en so-te-sê heeltemal verdwyn. Hierdie „Choanenrinnen" ontstaan volgens Fuchs deurdat die „Vomerpolster" gedeeltelik met die bokaakuitsteeksels versmelt en so 'n sekundêre verhemelte vorm. Al wat dan nog oorbly van die primitiewe choane is die „Choanenrinnen" wat heeltemal by die volwasse *Tropidonotus natrix*, soos deur Fuchs en Born (op. cit.) aangetoon, verdwyn.

Die neussakke open deur die sekundêre choane in 'n gemeenskaplike spleet wat die agterste gedeelte van die „Choanenspalten" moet voorstel.

Thäter (1910) meen dat Fuchs hom misgis wanneer hy beweer dat die voorste rande van die primitiewe choane versmelt om 'n

sekundêre verhemelte te vorm waardeur die choane na agter verskuif word. Hy meen dat die verskuiwing van die choane tewyte is aan die opheffing van die embrionale kopkromming. Daar sou dan in die ontwikkeling by slange geen uitgesproke „Choanenspalten" optree nie. Volgens Fuchs (1911) was die embrios van Thäter te oud en het die „Choanenspalten" reeds verdwyn.

DEKBENE IN DIE MONDDAK.

Die praemaxillare is hier 'n groot ongepaarde been (fig. 5), wat voor effens onder die nasale uitsteek en die voorste afgrensing van die skedel en van die verhemelte vorm. Aan die kante besit dit twee praenasaalvleuels wat die nasalia bereik en die voorste gedeeltes van die neussakke lateraal en ventraal stut. Na agtertoe wyk die praenasaalvleuels verder weg van die nasalia sodat 'n apertura nasalis externa waardeur die vestibulum na buitetoe open gevorm word. Die liggaam van die praemaxillare eindig spits na agter en is tussen die vomers ingekeil. Dit besit 'n mediane uitsteeksel wat tussen die neussakke dorsaalwaarts strek en in hegte verbinding met die nasalia tree. Hierdie uitsteeksel vorm 'n benige septum voor die kraakbenige septum nasi. Die praenasaalvleuels bereik nie die praefrontale nie, sodat dit van die voorste wand van die apertura nasalis externa uitgesluit word. Die teenoorgestelde geld vir *Typhlops bituberculatus* (Haas, 1930) waar die aperturae nasales meer ventraal geleë is omdat die praenasaalvleuels teen die praefrontale lateraal stoot en 'n voorste wand vir die openinge vorm. Agter die praenasaalvleuels gee die praemaxillare twee syhorings af wat saam met die septomaxillaria die agterste wande van die aperturae nasales externae vorm.

Die septomaxillare is 'n gepaarde been en is by alle slange besonders groot omdat dit 'n benige kapsel vir die orgaan van Jacobson vorm. Die voorste gedeelte dra twee uitsteeksels : een mediaan en die ander lateraal. Eersgenoemde lê dig teenaan die praemaxillare, en laasgenoemde is met die praefrontale verbind ; saam met laasgenoemde vorm dit die sywand van die apertura nasalis externa. Heel voor dien die septomaxillare as 'n ventrale stut vir die cartilago cupolaris, en mediaan strek dit tussen die neussakke op en vind aanhegting aan die nasale. Die septum nasi lê tussen hierdie mediane stygende gedeeltes van die septomaxillaria. Op die verhouding van die septomaxillare tot die orgaan van Jacobson is reeds by die beskrywing van laasgenoemde gewys. Die agterpunt van die septomaxillare vertoon in dwarssnitte as 'n vertikaalstaande staf, wat lateraal van die orgaan van Jacobson geleë is. Die ventrale punt van hierdie staf word deurboor deur die ductus nasolacrimalis en eindig as drie spits punte wat teen die frontale stoot.

Die vomers besit elk twee lateraalgerigte vleuels, en die mediane agterpunte is ventraal, net agter die voorpunt van die rostrum parasphenoidale geleë. Die twee vomers is mediaan deur hegte bindweefsel met mekaar, asook aan die mediale gedeelte van die palatinum, verbind.

Die palatinum is 'n sekelvormige been, bestaande uit 'n laterale en mediale gedeelte, eersgenoemde waarvan teen die maxillare, en laasgenoemde teen die vomer stoot (fig. 5). Die been is los verbind met die praefrontale, frontale en parasphenoïed, en sy agterpunt pas in die gevurkte voorpunt van die pterygoïed.

'n Transversum makeer geheelenal, en volgens Haas (1930) is dit die geval by alle *Typhlopidae* en *Leptotyphlopidae*: by hulle het die palatinum die funksie van die transversum oorgeneem. Haas meen dat Lakjer wat 'n transversum noem, die laterale gedeelte van die palatinum as sodanig beskou het. By ander slange behalwe bogenoemde twee families kom in die reël 'n transversum voor soos deur Peyer, Bäckström en Brock (op. cit.) by *Vipera aspis*, *Tropidonotus natrix* en *Leptodeira hotamboia* aangetoon. Dunn en Tihen (1944) wys op die aanwesigheid van 'n transversum by *Liotyphlops albirostris*, en hulle gee aan die hand dat hierdie been by 'n familie soos die Typhlopidae moontlik met die palatinum versmelt het.

Die maxillare is 'n dik beenstaf, lateraal van die praefrontale geleë, met aan sy dorsale vlak 'n diep gleuf waarin die sygedeelte van die palatinum geleë is (fig. 6). Die ramus maxillaris V verlaat die maxillare heel voor, en op hierdie plek is die been heeltemal deur digte bindweefsel omring wat dit aan die kapsel om die glandula harderiana verbind. Vanaf die voorpunt van die maxillare strek 'n sterk verbeende (!) ligament wat eersgenoemde met die septomaxillare en die horings van die praemaxillare verbind (fig 5). Die mediale gedeelte van die ligament bly vindweefselig. Die agterpunt van die maxillare is breed en dra van vyf tot ses tande, dit is trouens die enigste tanddraende been by *Typhlops*.

Die pterygoïed is 'n, in dwarssnitte rond verskynende been wat vanaf die palatinum tot agter die occipitaal wyk verby strek. Voor is dit gevurk vir opname van die palatinum en verloop dan ventrolateraal van die skedelbasis na agtertoe. By *Typhlops delalandii* is net so min as by ander species 'n basipterygoïedgewrig aanwesig, en die pterygoïed is agter alleen deur middel van 'n ligament aan die voorpunt van die quadraat verbind. 'n Soortgelyke toestand heers by *Leptotyphlops nigricans* (Brock 1932) waar die pterygoïed ook nie teen die quadraat stoot nie. Dit skyn dus asof die *Typhlopidae* sowel as die *Leptotyphlopidae* wat hierdie eienskap betref, van ander slange waar die pterygoïed agter teen die quadraat stoot, verskil (*fide* Gadow, 1920)

Dekbene in die Norma dorsalis cranii

Die nasale is 'n groot gepaarde been wat die hele voorste gedeelte van die norma dorsalis cranii en die dorsale wande van die aperturae nasales externae vorm. Die mediane agterpunte van die nasalia stoot kaudaal onder die voorpunte van die frontalia in en antero-mediaan word hulle deur die versmelte praemaxillaria effens uitmekaar gedruk. Die twee helftes van die nasale word mediaan deur sterk bindweefsel met mekaar verbind, en saam met die praemaxillare vorm dit heel voor in die snoet 'n benige kapsel vir die

glandula nasalis lateralis. Dorsaal word die nasalia deur takke van Va wat die huid innerveer deurboor.

Die frontale is 'n groot, gepaarde been, vorm die hele middelste gedeelte van die norma dorsalis cranii en saam met die parietale vorm dit die benige sywand van die skedel in die orbitotemporaalwyk. Dorsaal is die twee helftes deur middel van hegte bindweefsel met mekaar verbind, en die partes descendentes strek ventraalwaarts en stoot onder die brein teenmekaar sodat 'n benige kapselsilinder vir die brein gevorm word. Lateraal is die frontale deur middel van los bindweefsel aan die praefrontale asook aan die bindweefselkapsel om die glandula harderiana verbind. Die nervus ophthalmicus profundus, Va, en die nervus opticus verlaat die skedel deur die foramen opticum in die ventro-laterale gedeelte van die frontale, kaudaal van die agterste laterale punt van die praefrontale (fig. 7). Haas (1930) beskryf twee foramina in die frontale by *Typhlops punctatus*; deur die voorste gaan die nervus opticus en deur die agterste takke van V (profundus?). Kaudaal word die frontale breër en is blykbaar in hegte naatverbinding met die parietale. Dit skyn of hier 'n mate van versmelting tussen die frontale en parietale is.

Die versmelte parietalia (fig. 6), vorm die grootste benige komponent van die skedel. Die versmelting tree blykbaar eers baie laat op, want by 'n jeugdige *Typhlops delalandii-serie* is die twee parietalia nog nie heeltemal versmelt nie; dit is trouens nog vir die grootste gedeelte parig. Die partes descendentes van die parietale strek langs die kante om tot hulle die basisphenoïed bereik en agter die frontale die benige sywand van die skedel vorm. Heel agter verkry die parietale hegte verbinding met die prooticum en bedek die voorste sygedeelte van die supraoccipitale. Haas (1930) wys op die aanwesigheid van 'n gepaarde parietale by 'n volwasse *Typhlops braminus* (bevestig deur Mookerjee en Das (1932) en Mahendra (1936)). By *Typhlops lumbricalis* (Hoffmann, 1890) en *Typhlops punctatus* (Haas, 1930) heers 'n soortgelyke toestand as by *Typhlops delalandii* omdat die parietalia ook hier tot een groot been versmelt het. Versmelte parietalia is blykbaar die gewone toestand, want volgens Gadow (op. cit.) is die parietalia altyd versmelt. Mahendra (op. cit.) beskou die onversmelte toestand as primitief en nie as aangepas nie, want volgens hom is daar geen verskil in die leefwyses van die verskillende species van die *Typhlopidae*, waarmee hierdie toestand kan saamhang nie.

Die praefrontale vorm die hele voorste gedeelte van die benige sywand van die skedel en is beweeglik met die frontale verbind. Dit staan in hegte verbinding met die nasale en septomaxillare, en die agterste gedeelte dien as 'n laterale stut vir die lamina orbitonasalis. Die ductus nasolacrimalis deurboor die ventrale punt van die praefrontale, sodat die lacrimale vermoedelik in die praefrontale ingelyf is (vgl. de Villiers, 1939, oor Acontias).

Oorkapsel en Geluidgeleidende Apparaat.

By *Typhlops delalandii* is in die volwasse toestand net een oorkapselelement te onderskei, die prooticum. Dit besit voor twee uitsteeksels, 'n ventrale wat aan die basisphenoïed en 'n dorsale wat aan die parietale verbind is (fig. 8). Tussen die twee uitsteeksels verlaat Vb en Vc die skedel; Va verloop intrakraniaal vorentoe, gaan deur die foramen opticum en word agter van Vb en Vc deur die ventrale uitsteeksel van die prooticum geskei. Dié gedeelte van die prooticum wat die voorste, mediane wand van die oorkapsel vorm, word deur twee foramina acustica deurboor. Verder agtertoe word die mediaan-dorsale wand van die oorkapsel deur die supraoccipitale, en die mediaan-ventrale gedeelte deur die exoccipitale gevorm. Aan laasgenoemde twee skedelelemente is die prooticum deur middel van kraakbeenstroke geheg. Die fenestra ovalis is geleë tussen die prooticum en exoccipitale (fig. 11); die agterpunt van eersgenoemde wyk na die kant toe uit en eindig lateraal van die exoccipitale dorsaal van die quadraat.

Volgens Haas (1930) versmelt die prootica by *Typhlops braminus* en *Typhlops bituberculatus* met die ex- en supraoccipitale. Mahendra (1936) weerspreek Haas se stelling en beweer dat by *Typhlops braminus* die prooticum nie met die bene van die occipitaalwyk versmelt nie. *By Typhlops delalandii* kon 'n mate van versmelting tussen die prooticum en supraoccipitale aangetoon word. Haas (1930) beskryf by *Typhlops punctatus* sogenaamde „Schaltknochen" wat tussen prooticum, basioccipitale en exoccipitale geleë is. By *Typhlops delalandii* kon sodanige bene nie aangetoon word nie.

Volgens Parker (1878, gesiteer uit Peyer) tree daar in die oorwyk by *Tropidonotus natrix* vier selfstandige bene in die ontwikkeling op: prooticum, opisthoticum, epioticum en die sogenaamde „alisphenoïed" (?). By die volwasse toestand (Hoffmann, op. cit.) makeer 'n aparte opisthoticum omdat dit met die exoccipitale versmelt, dieselfde geld vir die epiotica en die supraoccipitalia, en die „alisphenoïed" en die prooticum. Peyer (op. cit.) kon 'n selfstandige prooticum en opisthoticum in die ontwikkeling van *Vipera aspis* aantoon, maar 'n aparte epioticum kon hy nie vind nie. Hy beskryf die „alisphenoïed" van Parker, maar beskou dit as 'n deel van die prooticum. Bäckström (op. cit.) beskryf 'n „alisphenoïed" en 'n opisthoticum by *Tropidonotus natrix*, hy beskou die „alisphenoïed" as 'n deel van die supraoccipitale, en stem nie saam met Peyer dat dit 'n deel van die prooticum is nie, want dit ontstaan by *Tropidonotus natrix* heeltemal apart daarvan. Of die ventrale uitsteeksel van die prooticum by *Typhlops delalandii* as die homologon van Parker en Peyer se „alisphenoïed" beskou kan word, is uit die volwasse toestand nie duidelik nie, want hier is dit reeds volledig met die prooticum versmelt. Haas (1930) skryf van 'n moontlike laterosphenoïed wat in die voorste gedeelte van die prooticum ingelyf is.

Soos blyk uit bogenoemde gegewens het daar geen sekerheid oor die homologie van die sogenaamde „alisphenoïed" by slange

bestaan nie. Brock (1929) beskryf 'n kraakbenige rif van die basaalplaat waarteen 'n benige struktuur wat met die prooticum versmelt en deel van die sywand van die foramen vir V begrens, geleë is. Dié kraakbenige rif beskou sy as 'n basitrabekulaaruitsteeksel, en die benige struktuur homologiseer sy met die „alisphenoïed" van W. Parker. Sy gee voorkeur aan die naam epipterygoïed, want dit het dieselfde verhoudings tot senuwees en bloedvate soos 'n egte epipterygoïed. In 'n later werk oor *Acontias meleagris* (1941) het sy haar mening gewysig, want by *Acontias* kom dieselfde struktuur as by slange voor en buitendien het *Acontias* 'n egte epipterygoied en basitrabekulaaruitsteeksel. Die been by slange is dus nie 'n epipterygoïed of 'n „alisphenoïed" soos sy eers vermoed het nie, maar 'n verbening in die sywand van die oorspronklike chondrocranium soos by *Acontias* (vgl. ook v.d. Merwe, 1944 oor Acontias). Brock stel dus voor dat die verbening liewers laterosphenoïed moet genoem word om aan te toon dat dit nie 'n viscerale element is nie.

Die geluidgeleidende apparaat bestaan uit 'n stapes met 'n groot voetplaat wat in die fenestra ovalis lê en 'n steel wat artikuleer met 'n uitsteeksel wat kontigu is met die os quadratum en cartilago quadrata, sodat laasgenoemde se bewegings op die columella auris oorgedra word (fig. 9 en 10). Die stapessteel wat effens S-vormig gebuig is se proksimale gedeelte is benig, maar verder na agtertoe toon dit 'n geleidelike oorgang van perichondrale been na kraakbeen. Die distale agterpunt is nie verkraakbeen nie, en verskyn as 'n voorkraakbenige stadium van veselkraakbeen (fig. 10), dit is synoviaal verbind met bogenoemde uitsteeksel. Laasgenoemde vertoon dieselfde histologiese struktuur as die agterpunt van die stapessteel. Die stapesvoetplaat lê skynbaar binne-in die labyrinthholte (fig. 11), omdat die prooticum en exoccipitale in die ontogenie vermoedelik ventraal om die voetplaat gegroei het. Bogenoemde uitsteeksel na die quadraat noem Parker (op. cit.) 'n „stylohyale" en Brock (1929) meen dat dit van die columella afkomstig is, en sekundêr met die quadraat versmelt het. Wat sy homologie betref is daar geen duidelikheid nie. Parker (gesiteer uit Brock) beskou die „stylohyale" as 'n extracolumellare wat van die stapes losgeraak het. Brock (1929) kon geen extracolumellare by *Leptodeira hotamboia* aangetoon nie, en volgens haar kon Okajima (1915) dit by *Trigonocephalus* ook nie aantoon nie; hy beskou die „stylohyale" bloot as 'n uitsteeksel van die pars quadrata palatoquadrati. Peyer (op. cit.) beskryf 'n „stylohyale", maar dit sou eers by latere stadia optree. Dat dit egter 'n deel van die columella voorstel, is volgens hom baie waarskynlik. Brock (1929) homologiseer die „stylohyale" met die processus dorsalis en intercalare van ander reptiele en sy staaf haar stelling deur te wys op die verhouding van die chorda tympani tot die extracolumellare en processus dorsalis by akkedisse. As die uitsteeksel 'n extracolumellare voorstel dan moet die senuwee dorsaal daarvan verloop, wat egter nie die geval by *Leptodeira hotamboia* is nie. Dit maak dus die homologie van die „stylohyale" met die extracolumellare reeds verdag. De Beer (1937) is dieselfde standpunt toegedaan en meen dat die „stylohyale" 'n processus

dorsalis is wat nie soos by akkedisse met die crista parotica versmelt het nie, maar met die quadraat soos by *Sphenodon* en *Crocodilus*. Bäckström (op. cit.) beskryf 'n „stylohyale" en homologiseer dit met die processus internus van die extracolumellare by akkedisse; dit verbeen saam met die quadraat by *Tropidonotus natrix*. Versluijs (1936) beskou die „stylohyale" as 'n gereduseerde extracolumellare. Na aanleiding van Rice (1920) en Brock (1929) se werk, dat die stapes verbeen en die extracolumellare altyd kraakbenig bly is ek geneig om die agterpunt van die stapessteel en „stylohyale" by *Typhlops delalandii* wat selfs in die volwasse toestand nie verkraagbeen nie, as die homologon van minstens 'n deel van die extracolumellare van akkedisse te beskou.

Die ramus hyomandibularis VII by *Typhlops delalandii* verloop in 'n ekstrakapsulêre ruimte van die oorkapsel ventraal van die stapesvoetplaat (fig. 11) en bo-oor die stapessteel, dan neem dit 'n mediane posisie met betrekking tot laasgenoemde in en buig dan effens ventraalwaarts totdat dit ventraal van die quadraat te lê kom. Hier gee dit die chorda tympani af wat latero-dorsaal van die mondhoeke vorentoe verloop en die onderkaak deur 'n kanaal in die processus retroarticularis ingaan.

Occipitaalwyk.

Die supraoccipitale is 'n gepaarde been en neem geringe aandeel aan die vorming van die skedeldak agter die parietale. Dit is heeltemal deur die exoccipitale van die foramen magnum uitgesluit, word voor en lateraal deur die parietale bedek en vorm die dorsale en mediaan-dorsale wande van die middelste gedeelte van die benige oorkapsel. Die prooticum en exoccipitale is synchondroties met die supraoccipitale verbind. Mahendra (op. cit.) kon nie 'n supraoccipitale by die volwasse *Typhlops braminus* aantoon nie. Volgens Haas (1930) is die ex- en supraoccipitale by *Typhlops braminus* versmelt, maar Mahendra betwyfel dit; volgens hom is dié toestand alleen moontlik indien 'n aparte supraoccipitale, wat later met die exoccipitale versmelt, in die ontogenie aangetoon kan word.

Die exoccipitale is gepaard en vorm die dorsale en laterale wande van die foramen magnum; ventraal stoot dit teen albei kante van die basioccipitale, is synchondroties daaraan verbind en vorm die heel agterste gedeelte van die oorkapsel en skedeldak. Na agtertoe word die exoccipitale na die kantetoe breër sodat twee syvlerke wat bo-oor die agterpunte van die ossa quadrata lê, gevorm word. Postero-mediaan van die fenestra ovalis kom 'n groot foramen jugulare in die exoccipitale waardeur IX, X en XI die skedel verlaat (fig. 5 en 9), voor. Die nervus hypoglossus en vena jugularis interna verlaat die skedel deur aparte foramina in die agterste gedeelte van die exoccipitale.

Die basioccipitale vorm die heelagterste gedeelte van die skedelbasis; dit is 'n driehoekige ventraal konveks vertonende been wat aan die exoccipitale en prooticum grens en voor lateraal synchondroties met die para-basisphenoïedkompleks verbind is.

Postfrontale, Supraorbitale en Postorbitale.

Wat bogenoemde skedelelemente betref, toon slange baie variasie: by *Typhlops delalandii* is almal afwesig, en volgens Haas (1930 en '31) makeer 'n postfrontale by die *Typhlopidae* en *Leptotyphlopidae*; hy kon nie 'n postfrontale by *Typhlops punctatus* aantoon nie. By *Typhlops braminus* (Mahendra, op. cit.) beskryf hy 'n postfrontale, aanwesig as drie „klein brokkies" op die voorste buitenste grense van die parietale; of hierdie beentjies ook die postorbitale verteenwoordig, was vir hom nie duidelik nie. Dunn en Tihen (op. cit.) beskryf 'n supraorbitale by *Liotyphlops albirostris*; by *Tropidonotus natrix* (Bäckström, op. cit.) is dit afwesig. By *Python* is die praefrontale met die postfrontale verbind deur middel van 'n beenstuk wat deur Hoffmann (op. cit.) „supraorbitale" genoem word.

Skedelbasis.

Die dekbenige komponent van die skedelbasis, die parasphenoïed, is volkome met die basisphenoïed tot 'n groot driehoekige beenplaat wat die grootste gedeelte van die skedelbasis vorm, versmelt. Die voorpunt van die processus cultriformis van die parasphenoïed lê effens voor die choane en dig teenaan die partes descendentes van die frontalia, ventraal van die trabeculae cranii. Die kraniale gedeelte van die basaalbeen is konkaaf en sy kaudale gedeelte konveks. By die volwasse *Typhlops delalandii* is geen basipterygoïeduitsteeksels op die basaalbeen soos by *Pythonidae* (Haas 1931) aanwesig nie.

Die trabeculae cranii is die enigste kraakbene van die chondrocranium, met uitsondering van die neuskapsel, wat by die volwasse *Typhlops delalandii* behoue bly. Hulle verloop vanaf die septum nasi as twee aparte kraakbeenstawe, vasgedruk tussen die skedelbasis en die partes descendentes van die frontalia, na agtertoe en eindig dan heeltemal vry. Die skedel is dus platibasies soos by meeste slange. Hierdie toestand hang saam met die verdwyning van die interorbitaalseptum en moontlik ook met die ruim verbeende breinkas in die orbitotemporaalwyk. De Beer (1937) meen dat platibasie, die primitiewe toestand daarstel en dat tropibasie hieruit ontwikkel het; hy gee egter toe dat platibasie ook heeltemal sekundêr kan ontstaan. As ons aanneem dat slange van die tropibasiese akkedisse ontwikkel het, dan moet die platibasie van eersgenoemde sekundêr wees en kan moontlik beskou word as 'n „parsiële neoteniese" verskynsel terugwysend op toestande nog primitiewer as dié by akkedisse.

Quadraat en Onderkaak.

Die quadraat is 'n stafvormige been met 'n groot murgholte en is agter deur middel van 'n los bindweefselkussing direk met die prooticum en exoccipitale verbind omdat 'n supratemporale soos by alle *Typhlopidae* (vgl. Haas 1930), afwesig is. Die voorpunt is breed en besit twee uitsteeksels: 'n dorsale wat vir spieraanhegting dien en 'n groter ventrale met 'n kraakbenige gewrigsvlak vir

artikulasie met die onderkaak. Die agterste gedeelte van die pars quadrata palatoquadrati bly kraakbenig (fig. 10).

Die onderkaakhelftes is antero-mediaan deur middel van die versmelte cartilagines Meckelii, en deur 'n sterk bindweefselband met mekaar verbind. Die groot onderlinge beweeglikheid van die twee onderkaakhelftes wat meeste slange kenmerk ontbreek dus by *Typhlops delalandii* en moet as moontlike weerspieëling van die dier se bekende fossoriale lewenswyse beskou word. Vier dekbene kan in die onderkaak onderskei word : dentale, spleniale, koronoïed en angulare. Die articulare is groter as die dekbene en agter vorm dit die kaakgewrig met die quadraat, die voorpunt is ingekeil tussen die sykante van die dentale en spleniale. Haas (1930) meen dat 'n supra-angulare en dermarticulare (goniale) met die articulare versmelt geraak het. Die voorpunt van die koronoïed is gevurk en het 'n groot processus coronoideus wat vir spieraanhegting dien. Die dentale en spleniale vorm die voorste gedeelte van elke onderkaakhelfte. Die angulare is die kleinste van die onderkaakbene en vorm 'n gedeelte van sy mediaan-ventrale rand. Die voorste gedeelte van die angulare lê oor 'n spleet in die articulare waarin die ramus mandibularis V, chorda tympani VII en die kraakbeen van Meckel verloop ; verder na agtertoe versmelt dit met die articulare. Die ramus mandibularis V deurboor 'n kanaal in die articulare en verloop dan vorentoe in die onderkaak.

SKEDELKINESE.

Om die kinese te beskryf, is dit nodig om eerstens die vernaamste spiere wat by die kinese betrokke is te behandel. Dit is egter al deur Haas (1930) en Lakjer (1926) by ander Typhlops-species gedoen, en aangesien die toestande by *Typhlops delalandii* in hoofsaak met hulle beskrywinge ooreenstem, is dit onnodig om weer op volle besonderhede in te gaan. Wat volg, is net 'n beknopte oorsig van toestande soos waargeneem by *Typhlops delalandii.*

Die m. depressor mandibulae ontspring aan die agterste dorsolaterale kant van die parietale, sy vesels verloop eers in 'n ventrolaterale rigting buiteom die m. levator pterygoidei, buig dan ventraalwaarts om en heg aan die processus retroarticularis.

Die m. protractor pterygoidei ontspring aan die agterpunt van die pterygoïed, en sy vesels verloop vorentoe rondom die pterygoïed en vind aanhegting aan die sykante van die skedelbasis.

Die m. levator pterygoidei (m. adductor posterior van Lakjer) het sy oorsprong aan die kante van die prooticum en parietale asook aan die quadraat. Dit is die grootste van al die kouspiere en bedek die hele sywand van die skedel in die orbitotemporaalwyk ; sy vesels verloop in 'n rostrale rigting en vind aanhegting aan die maxillare.

Die m. retractor pterygoidei ontspring aan die sykant van die parientale ; sy vesel verloop vorentoe mediaan van die m. levator pterygoidei en heg aan die voorpunt van die pterygoïed en aan die palatinum.

Die m. retractor quadrati strek vanaf die dorsale uitsteeksel van die quadraat; sy vesels verloop eers ventraalwaarts en buig dan om na die middellyn, sodat dit die m. protractor pterygoidei van ventraal bedek. Die spier ontspring ventraal aan die huid van die nekwyk.

MUSCULUS ADDUCTOR EXTERNUSGROEP.

(1) Die m. adductor mandibulae externus superficialis ontspring aan die boonste, laterale hoek van die frontale en sy vesels verloop dan buiteom die glandula harderiana, buig dan ventraalwaarts lateraal van die ramus maxillaris V en heg aan die articulare en koronoïed van die onderkaak. Te oordeel na sy verloop is dit 'n tipiese adductor mandibulae.

(2) Die m. adductor mandibulae externus medialis het sy oorsprong aan die boonste, laterale hoek van die parietale. Sy agterpunt skuif in tussen die voorkante van die m. depressor mandibulae en die m. levator pterygoidei en lê ventraal, dig teenaan die m. adductor mandibulae externus profundus; verder vorentoe kan die skeidingslyn tussen hierdie twee spiere nie meer aangetoon word nie. Die vesels verloop vorentoe lateraal van die ramus maxillaris V en is deur middel van 'n peesplaat aan die agterkant en bopunt van die processus coronoideus geheg.

(3) Die m. adductor mandibulae externus profundus ontspring aan die voorste vlak van die dorsale uitsteeksel van die quadraat. Die spier verloop vorentoe ventraal van die m. adductor mandibulae externus medialis en vind aanhegting aan die latero-dorsale kant van die articulare en die processus coronoideus. Hierdie spier is volgens Haas (1930) eintlik 'n retractor mandibulae in plaas van 'n adductor.

MUSCULUS ADDUCTOR INTERNUSGROEP.

(1) Die m. pseudotemporalis ontspring aan die voorste, laterale hoek van die parietale. Sy vesels verloop ventraalwaarts mediaan van die ramus maxillaris V en heg aan die articulare en agterste gedeelte van die koronoïed agter die aanhegting van die m. adductor mandibulae externus superficialis. Dit is 'n tipiese adductor van die onderkaak.

(2) Die m. pterygoideus het sy oorsprong aan die voorste syhoek van die maxillare en verloop mediaan ventraal van die onderkaak agtertoe en vind aanhegting aan die agterpunt van die processus retroarticularis.

KINESE VAN DIE SNOETWYK.

Voordat tot die bewegings as sodanig oorgegaan word, is dit nodig om 'n duidelike beeld te kry van verbindings tussen bene wat beweeglik teenoor die neurocranium en teenoor mekaar is. Die agterpunt van die quadraat is deur middel van los bindweefsel met die occipitaalwyk en prooticum verbind, 'n synoviaalholte is afwesig wat daarop dui dat die quadraat besig is om sy streptostylie te verloor. Die pterygoïed staan in hegte verbinding met die palatinum voor en is agter deur middel van 'n lang bindweefsel-band

met die quadraat verbind. Die sygedeelte van die palatinum is sodanig aan die maxillare geheg dat dit daarteen kan beweeg en die mediane gedeelte is effens beweeglik met die vomer verbind. Die vomer vind hegte aansluiting by die septomaxillare en laasgenoemde weer op sy beurt by die nasale dorsomediaan en die praemaxillare ventraal, meer na agtertoe is die septomaxillare uiters beweeglik aan die frontale geheg. Die praefrontale is deur middel van hegte bindweefsel met die nasale dorso-lateraal en die septomaxillare ventro-lateraal verbind. Die hele ethmoidaalwyk van die skedel vorm dus 'n hegte funksionele eenheid met uiters beperkte beweeglikheid tussen die bene onderling. Hierdie toestand hang saam met die fossoriale leefwyse van die dier. Dorsaal in die skedeldak is 'n duidelike mesokinetiese buigingslyn soos by *Python* (Versluijs 1912) tussen die frontale agter en die nasale en praefrontale voor aanwesig. Die hele snoetgedeelte van die skedel kan gevolglik effens in die mesokinetiese buigingslyn teenoor die skedeldak beweeg.

Die oopmaak van die bek geskied op die volgende wyse : die m. depressor mandibulae trek saam en trek die voorste gedeelte van die onderkaak af, die m. pterygoideus wat volgens Haas bloot 'n protractor van die onderkaak is, verskuif dit effens vorentoe. Hierdie beweging is noodsaaklik vir die vasvang van die prooi (vgl. Haas, 1930). Die m. protractor pterygoidei trek saam en verskuif die pterygoied vorentoe en boontoe sodat die palatinum effens, vorentoe beweeg en tegelykertyd ook 'n draaibeweging uitvoer. Die beweging van die palatinum word op die maxillare oorgedra, sodat die kaudale gedeelte van laasgenoemde effens vorentoe en na onder beweeg ; die tande kom dus in 'n gunstiger posisie om die prooi te kan gryp. Die beweging van die pterygoied word ook deur middel van die palatinum op die ethmoidaalwyk oorgedra, en die hele snoetgedeelte van die skedel lig nou in die mesokinetiese buigingslyn teenoor die res van die skedel sodat die mond maksimaal ge-open word.

Die toemaak van die bek geskied as volg : die m. depressor mandibulae verslap, die m. adductor mandibulae externus superficialis en m. pseudotemporalis trek saam en lig die onderkaak op. Tegelykertyd word die onderkaak ook effens agtertoe getrek deur die mm. adductor mandibulae externus profundus en medialis. Die m. levator pterygoidei kontraheer en verskuif die agterpunt van die maxillare effens agtertoe, opwaarts en binnetoe sodat dit behalwe die agterwaartse beweging ook 'n horisontale posisie met betrekking tot die skedel verkry. Die pterygoied en palatinum word deur die m. retractor pterygoidei effens na agtertoe getrek. Die palatinum draai in die teenoorgestelde rigting as met die oopmaak van die bek en ook dit help mee om die maxillare van uit die meer vertikale posisie in 'n horisontale te roteer. Die agterwaartse beweging van die palatinum en pterygoied word op die ethmoidaalwyk oorgedra wat dan sak. Tegelykertyd trek die m. retractor quadrati die quadraat effens agtertoe sodat die onderkaak nog meer na agter verskuif, en die bek gaan toe.

Volgens Haas (1930) is die m. levator pterygoidei die enigste spier wat die maxillare na agter kan trek, en sou die m. pterygoideus nie aan die proses deel neem nie, omdat die voorpunt van die maxillare nie uit posisie beweeg nie. Dit is egter net 'n halwe waarheid aangesien die voorpunt van die maxillare tog effens vorentoe en agtertoe kan beweeg. Die beweging is egter nie so uitgesproke dat die m. pterygoideus as 'n funksionele retractor van die bokaak beskou kan word nie, maar liewers dat dit die voorpunt van die maxillare effens na sy oorspronklike posisie met die toemaak van die bek aftrek. Die aanhegting van die m. pterygoideus aan die maxillare moet dan liewers soos deur Haas aangetoon as die vaste punt beskou word. Die agterste bene van die Typhlopsskedel is almal baie heg aan mekaar verbind en vorm 'n sterk, geslote breinkas.

Uit bostaande beskrywing blyk dit dat die kinese by *Typhlops* in wese ooreenstem met dié by *Python* soos Versluijs (op.cit.) beskryf. Volgens hom is die mesokinetiese toestand by slange herleibaar van die metakinetiese van akkedisse. Die mesokinetiese toestand by sommige akkedisse sou ontstaan het as 'n aanpassing aan die fossoriale leefwyse van die diere ; en omdat slange volgens Versluijs van borende akkedisse sou afgestam het, sou verwag word dat hulle en veral die borende slange soos die *Typhlopidae* en *Leptotyphlopidae* uitgesproke mesokineties moet wees. 'n Studie van die kinese by hierdie vorme loënstraf egter die aanname van Versluijs. Die skedel van *Leptotyphlops nigricans* (Brock 1932) is heeltemal akineties, en by *Typhlops delalandii* is die quadraat besig om sy streptostylie te verloor en beweeg blykbaar baie min of glad nie saam met die res van die palatoquadratum nie, aangesien die pterygoied hom nie eens bereik nie. Blykbaar is ook *Typhlops delalandii* op pad na verlies van skedelkinese, en hierdie omstandigheid weerspreek die vermeende primitiviteit van hierdie egte fossoriale slang. Dit is dus duidelik dat mesokinese nie kon ontstaan het as gevolg van 'n boorleefwyse nie, maar dat laasgenoemde juis tot gevolg het die algehele verlies van skedelkinese.

OPSOMMING.

1. 'n Aparte foramen apicale ontbreek.
2. Foramen mediale nasi aanwesig.
3. Processus alaris inferior goed ontwikkel, maar die processus alaris superior afwesig.
4. Fenestra lateralis nasi afwesig.
5. Daar is geen verbinding tussen die lamina orbitonasalis en die septum nasi nie.
6. Hypochoanaalkraakbeen afwesig, maar by *Typhlops delalandii* lê 'n kraakbeenstrook lateraal van die cartilago ectochoanalis ; laasgenoemde kraakbeen versmelt met die lamina orbitonasalis en nie met die cartilago ectochoanalis nie ; dit is dus nie homoloog met die hypochoanaalkraakbeen nie.
7. 'n Groot processus maxillaris posterior aanwesig en versmelt met die lamina orbitonasalis.
8. Cartilagines paraseptales, soos by alle slange, afwesig.
9. Die praemaxillaria is versmelt tot 'n groot ongepaarde been.
10. Die septomaxillare is 'n gepaarde been en vorm 'n benige kapsel om die orgaan van Jacobson.

11. Die palatinum is 'n sekelvormige been en dra die beweging van die pterygoïed op die maxillare oor. Dit lê 'n klein entjie trogvormig oor die choanegang.
12. 'n Transversum is afwesig.
13. Die maxillare is die enigste been wat tande dra.
14. Die pterygoïed stoot nie agter teen die quadraat soos by meeste slange nie.
15. In die volwasse toestand kon net een oorkapselelement, die prooticum, onderskei word.
16. Parker se „stylohyale" is aanwesig, en die stapes artikuleer hiermee.
17. Parietalia versmlet tot een groot been ; die versmelting tree blykbaar eers laat in die ontwikkeling op.
18. Die ramus ophthalmicus profundus, Va, en nervus opticus verlaat die skedel deur 'n gemeenskaplike foramen, in the frontale geleë.
19. Die ductus nasolacrimalis deurboor die ventrale punt van die praefrontale, sodat 'n lacrimale vermoedelik in die praefrontale ingelyf is.
20. Postfrontale, supraorbitale en postorbitale makeer.
21. Temporaalbene makeer hoegenaamd.
22. Die skedel is platibasies, 'n toestand wat saamhang met die verdwyning van die interorbitaalseptum.
23. Die parasphenoïed en die basisphenoïed is versmelt.
24. Die cartilagines Meckelii is voor mediaan versmelt.
25. Die onderkaak bestaan uit vier dekbene: dentale, spleniale, koronoïed, angulare, en 'n substitusie been, die articulare. 'n Goniale het vermoedelik met die articulare versmelt.
26. Die skedel is mesokineties.
27. Ten spyte van die streptostylie beweeg die quadraat blykbaar baie min of glad nie saam met die res van die palatoquadratum nie, aangesien die pterygoïed hom nie eens bereik nie. Blykbaar is *Typhlops* op pad na die verlies van skedelkinese, en dit weerspreek die vermeende primitiviteit van hierdie egte fossoriale slang.

Hiermee wens ek my innige dank aan dr. V. Fitzsimons te betuig vir informasie aangaande die taksonomie van die ondersoekte species wat hy goedgunstiglik aan my verstrek het. Ook wens ek my erkentlikheid aan prof. C. G. S. de Villiers en dr. M. E. Malan te betuig vir aanmoediging, leiding en kritiek.

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LYS AFKORTINGS.

A.C.I., arteria carotis interna; A.N.E., apertura nasalis externa; A.O.J., afvoergang van orgaan van Jacobson; BAOCC., Basioccipitale; B.P., basisphenoïed parasphenoïed; C.CU., cartilago cupolaris; C.E., cartilago ectochoanalis; CHG., choanegang; C.QUA., cartilago quadrata; D.PROOT., dorsale uitsteeksel van prooticum; EOCC., exoccipitale; F.D.N., fenestra dorsalis nasi; F.JUG., foramen jugulare; F.M.N., foramen mediale nasi; F.N.,

fenestra narina; F.O., foramen opticum; F.OV, fenestra ovalis; F.PROOT, foramen prooticum; FR., frontale; F.R.L.N., foramina vir ramus lateralis nasi Va; GD.H., glandula harderiana; GD.N.L., glandula nasalis lateralis; G.G., ganglion gasseri; LH., labyrinthholte; L.ON, lamina orbitonasalis; L.T.A., lamina transversalis anterior; M.A.M.E.P., m. adductor mandibulae externus profundus; MAX., maxillare; M.D.M., musculus depressor mandibulae; M.L.PT., musculus levator pterygoidei; M.P.PT., musculus protractor pterygoidei; M.PT., musculus pterygoideus; NA., nasale; NK. neuskapsel; N.OP., nervus opticus; N.VN., nervus vomero-nasalis; O.D.NL., opening van ductus nasolacrimalis; O.J., orgaan van Jacobson; P.A.I., processus alaris inferior; PAL., palatinum; PAR., parietale; PCH., perichondrale been; P.CU., processus cultriformis van parasphenoïed; P.M.P., processus maxillaris posterior; PMX., praemaxillare; P.RA., processus retroarticularis; PRF., praefrontale; PROOT., prooticum; PT., pterygoied; QUA., quadraat; R.H., ramus hyomandibularis VII; R.L.N., ramus lateralis nasi; R.M.N., ramus medialis nasi; R.O.P., ramus ophthalmicus profundus Va; R.V.L., recessus ventro lateralis-gedeelte van afvoergang; SMX., septomaxillare; S.N., septum nasi; SOCC., supraoccipitale; ST., stapes; STV., stapesvoetplaat; STY., „stylohyale"; SYN.H., synoviale holte; TRA., trabecula; VO., vomer; V.PROOT., ventrale uitsteeksel van prooticum.

FIGURE.

Fig. 1.—Grafiese rekonstruksie van die neuskapsel (dorsaal). Fig. 2.—Grafiese rekonstruksie van die neuskapsel (ventraal). Fig. 3.—Dwarssnit deur die skedel in die neuswyk om die orgaan van Jacobson te wys. Fig. 4.—Dwarssnit deur die skedel net agter die neuswyk. Fig. 5.—Grafiese rekonstruksie van die skedel (ventraal). Fig. 6.—Grafiese rekonstruksie van die skedel (dorsaal). Fig. 7.—Dwarssnit deur die skedel om die foramen opticum te wys. Fig. 8.—Dwarssnit deur die skedel net voor die oorkapsel. Fig. 9.—Grafiese rekonstruksie van die oorkapsel en geluidgeleidende apparaat (ventraal). Fig. 10.—Dwarssnit deur die cartilago quadrata en agterste gedeelte van geluidgeleidende apparaat. Fig. 11.—Dwarssnit deur die oorkapsel.
AL DIE AFKORTINGS IN DIE FIGURE SOOS 'N VORIGE „LYS AFKORTINGS".

FIG.1

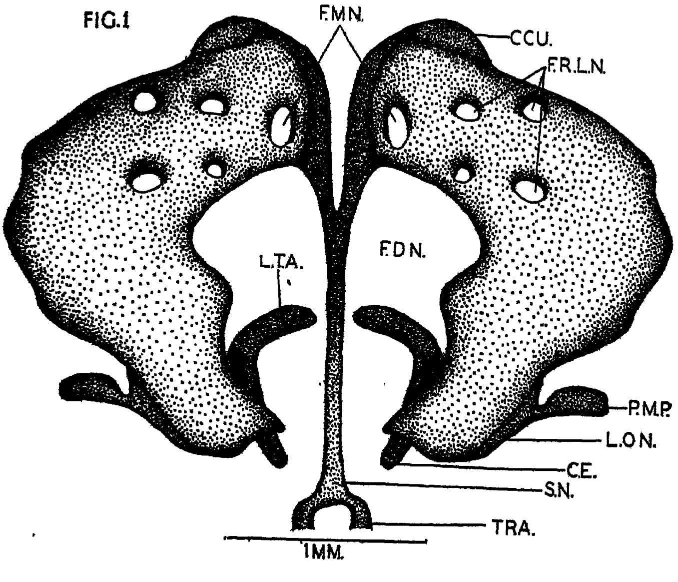


FIG. 2

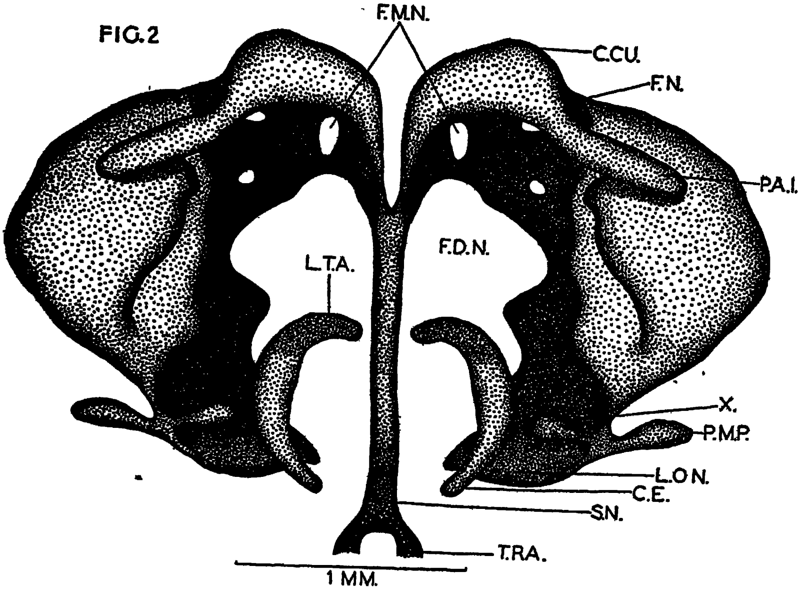
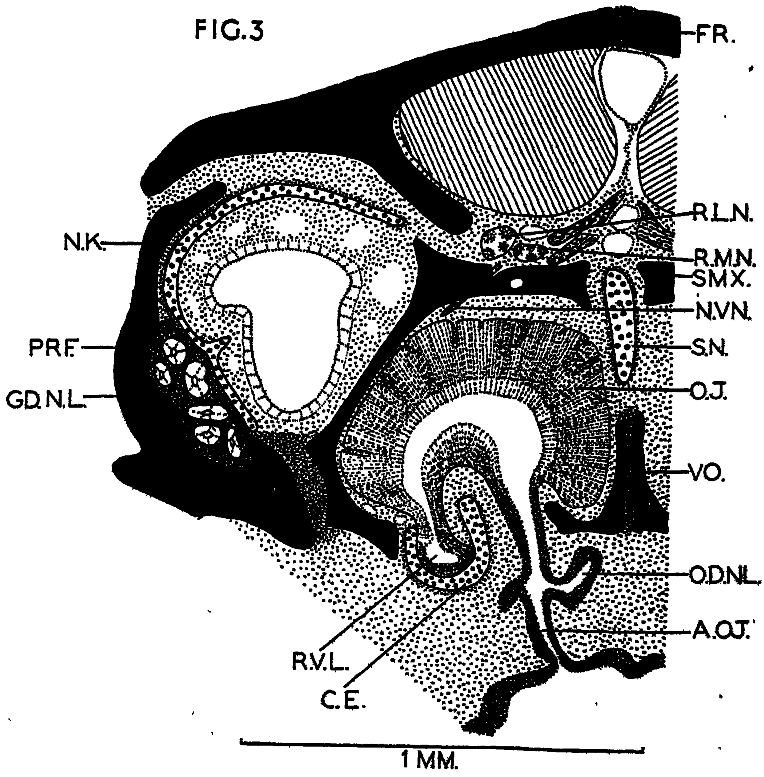

F.M.N.
C.CU.
F.N.
P.A.I.
L.T.A.
F.D.N.
X.
P.M.P.
L.O.N.
C.E.
S.N.
T.RA.
1 MM.

FIG. 3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R.L.N.
N.K.
R.M.N.
S.M.X.
N.V.N.
P.R.F.
S.N.
GD.N.L.
O.J.
V.O.
O.D.N.L.
A.O.J.
R.V.L.
C.E.
1 MM.

FIG. 4

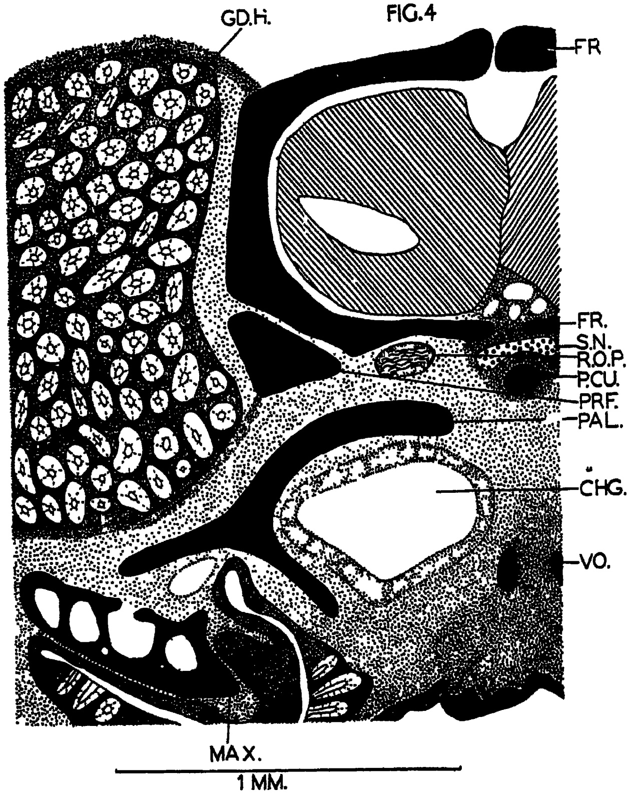


FIG 8

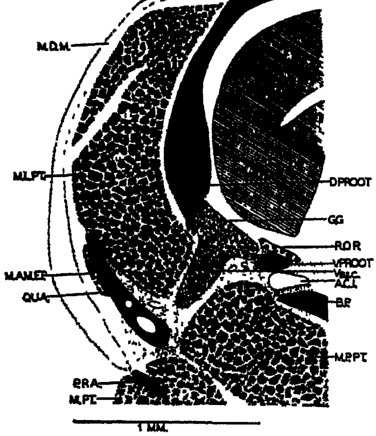
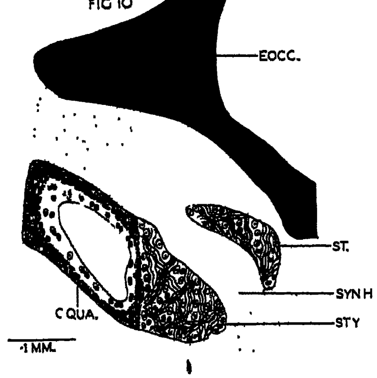


FIG 10



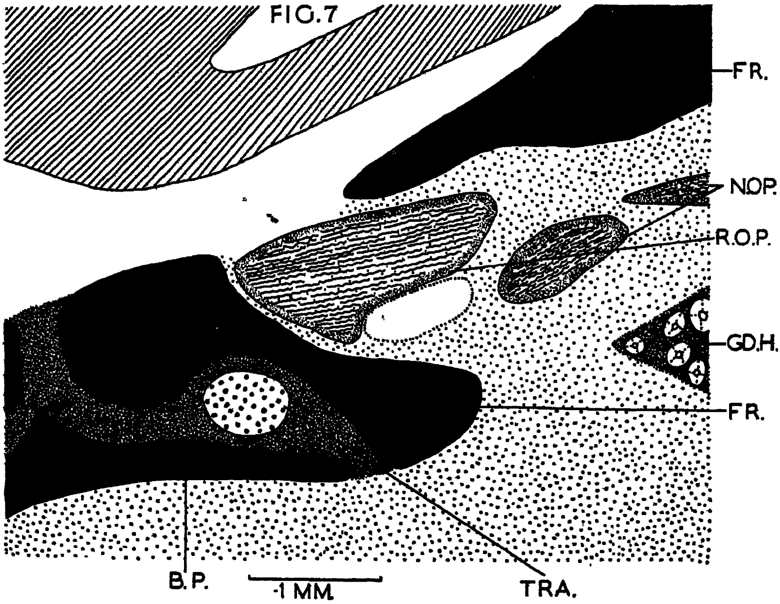
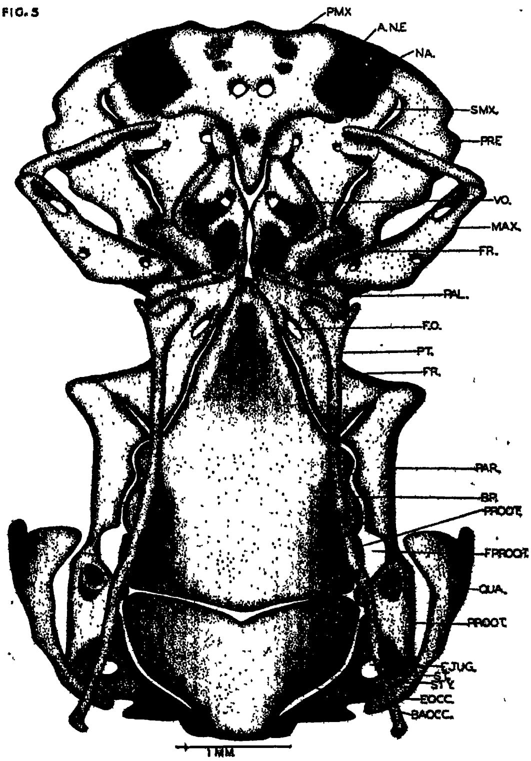

FR.
NOP.
R.O.P.
GD.H.
FR.
B.P.
·1 MM.
TRA.

FIG.7

FIG.5


PMX
A.N.E
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SMX.
PRE
VO.
MAX.
FR.
PAL.
F.O.
PT.
FR.
PAR.
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FPROOT.
QUA.
PROOT.
EJUG.
ST.Y.
EOCC.
BAOCC.
1 MM.

FIG.8

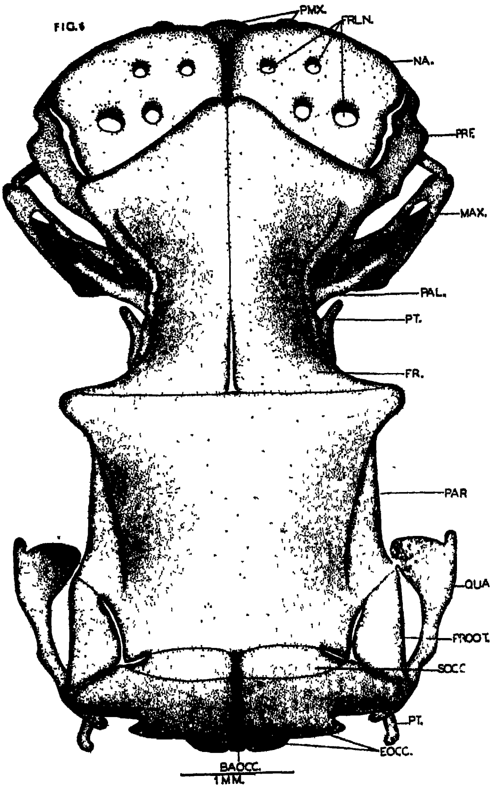


FIG.9

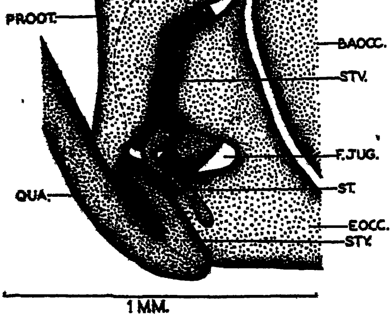
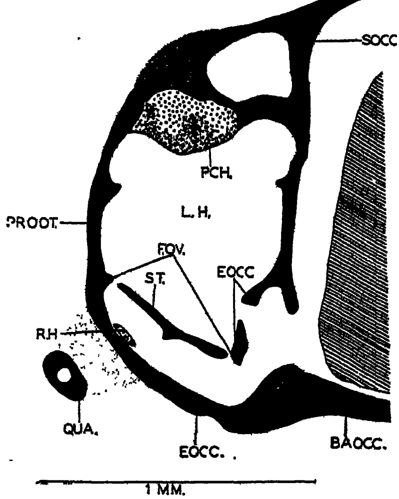


FIG.11



SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLV*,
pp. 141-142, *March*, 1949.

ROCK PAINTINGS AND THE ZIMBABWE CULTURE.

BY

PROF. C. VAN RIET LOWE

Read before Section E of the South African Association for the Advancement of Science, July 1948.

ABSTRACT.

In this contribution, the author drew attention to new discoveries of unusual prehistoric rock paintings in Southern Rhodesia and to the general resemblance between some of these and certain rock paintings recently recorded by the Abbé Breuil in South West Africa*. He also drew attention to apparent affinities between some of the Rhodesian figures and early types from North Africa and the Near East, and to the possibility that these newly discovered Rhodesian rock-paintings represent foreign intruders in search of mineral and other wealth *before Zimbabwe was built*, and therefore to the probability that the maladroitly built Zimbabwe ruins represent the climax which a succession of earlier culture-contacts between foreigners and local Natives reached in medieval times. The opinion was expressed that these contacts provided the Natives with much of the cultural heritage and inspiration which led them to build Zimbabwe and its related structures which now lie in ruins over so much of southern Africa.

It is suggested that a survey of the distribution of these paintings and the systematic exploration of the contents of the rock-shelters in which they occur may throw a great deal of light on the Pre-European mining and stone-building periods of the sub-continent.

Attention was also drawn to the tenuous evidence submitted in support of Miss Mary Boyle's thesis that the so-called "White Lady of Brandberg" was painted by an Egyptian or by a Cretan who knew the Egyptian mysteries in pre-Christian times—a claim with which the Abbé Breuil tends to sympathise. The author suggests that a closer study of local South West African Natives and their initiation ceremonies, especially those applied to females, may throw a flood of light on the ornaments carried and worn by the "White Lady" as well as on her bodily decorations. According to the Abbé, the "White Lady" is the last of a series of eleven superimpositions, among the earliest of which are typical "Bushman" paintings. It is therefore possible that the principal figure and her associates were painted by a later Bushman in recent times.

Finally a plea is made for more intensive archaeological exploration in Portuguese East Africa which is described as the principal gateway to the interior during the Pre-European mining and stone-building periods. The Colony of Mozambique is known to contain a wealth of rock-paintings and ruins of the Zimbabwe type, and major clues to successive cultural impacts during pre-European times must be expected to occur in this Colony. It is emphasised that archaeologists in the interior cannot hope to solve the problems raised by these new discoveries in any satisfying manner without the co-operation of their distinguished Portuguese colleagues.

NOTE: The full text of this paper is published in the Bulletin of the "Sociedade de Estudos da Colonia de Moçambique," April-September, 1948.

BREUIL, H.: "The White Lady of Brandberg, South-West Africa, Her Companions and her Guards." S. Afr. Archaeol. Bull. No. 9, Vol. III, pp. 2-11, 1948.

South African Journal of Science, *Vol. XLV*, *p.* 143, *March*, 1949.

NEW MIDDLE STONE AGE SITES NEAR UTRECHT, NATAL.

BY

Mr. B. D. Malan.

Read before Section E of the South African Association for the Advancement of Science, July 1948.

Abstract.

A new Middle Stone Age site on the Sandspruit about one mile from Utrecht, discovered in June 1947, by a party consisting of Professor C. van Riet Lowe, the Abbé H. Breuil, Mr. D. H. Bowden, and the author is described. At the suggestion of the discoverers the area was subsequently visited by Mr. S. Brenner, who extended his investigations over a somewhat wider area and found similar sites in nearby watercourses and on the farm Geluk. All these sites are erosion areas in which the bedrock is covered by some 10 to 15 feet of calcified sand and some two feet of humus. In places, small pockets of gravel lie between bedrock and the calcified sands. These gravels yielded a few pieces which are referred to the late Chelles-Acheul or possibly Fauresmith Culture. Middle Stone Age industry artefacts occur abundantly on the calcified sands and less abundantly in the upper half of the calcified sands.

The materials used are predominantly indurated shales of varying composition. Although some specimens are weathered to a cream colour and others to a slaty blue, the two groups present no typological differences and are considered to constitute a single cultural phase.

The artefacts include cores, blades and flakes of advanced technique and form, with prepared striking platforms. Tools described and illustrated include trimmed points, side and end scrapers, backed blades, *outils écaillés* and burins.

The culture represented here is referred to the Mazelspoort Culture described by Dr. E. C. N. van Hoepen under the name of Mossel Bay Culture. Attention is drawn to the identical materials used on the two sites and the presence in the Sandspruit collection of a facetted polyhedral stone, a type which is very abundant at Mazelspoort.

By these new discoveries the known distribution of the Mazelspoort Culture is extended into Natal. Further work is urged in order to fill in the considerable gap between the two areas, viz. Bloemfontein and Utrecht, where the culture is now known to have existed.

NOTE: The full text of this paper is published in the "S. African Archaeological Bulletin," December, 1948.

SOUTH AFRICAN JOURNAL OF SCIENCE, *Vol. XLV,*
p. 144, *March,* 1949.

PYGMIES.

BY
DR. M. D. W. JEFFREYS,

Read before Section E of the South African Association for the Advancement of Science.

ABSTRACT.

Professor Dart (1940) maintains that the Negro of Africa was preceded by two earlier peoples—one of which was a dwarf or pygmy species. Dr. Schweinfurth (1878) reached the same conclusion after describing the anatomical features of the Akka pygmies he met in the Nilotic Sudan.

The pygmies of Africa are distributed round the margins of the great equatorial forests of the Congo basin. It is not generally known that the pygmy type is found also in the Benue basin well to the north of the accepted range.

Bouchard (1944) reported the presence of a pygmy type among the Alantika and Chamba mountains forming the headwaters of the Benue. East of these ranges in the Savannah zone of the French Cameroons Vallois (1947) reported the existence of about a hundred of these little folk in the islands of forest still remaining there.

Professor Dart contends that steatopygia in Africa is one of the stigmata of a pygmy strain, and in 1938 I found in the village of Bambuluwe, Bamenda Division, British Cameroons, a number of steatopygous, dwarf women. Similar types are found in the Assimbo tribe in the neighbouring Mamfe Division, in the headwater forests of the Cross river.

The following table shows that Africa is particularly well represented by dwarf or pygmy genera.

	Feral	Domesticated
Dwarf buffalo	(B. caffer nanus)	Dwarf cattle.
„ antelope	(Neotragus pygmaeus)	
„ hippo	(Hippopotamus liberiensis)	
„ elephant		Dwarf goats.
„ crocodile		
„ dormouse	(Graphiurus nanus)	
„ leopard		Dwarf fowls.
„ goose		
„ chimpanzee	(Pan paniscus)	
	pygmies (Homo pygmaeus ?)	

MESON THEORY OF NUCLEAR FORCES

BY

ENG. M. P. P. DOS SANTOS.

Read to Section A, June, 1948.

APPLICATION OF RADIO-ACTIVE ISOTOPES

BY

DR. A. E. H. BLEKSLEY.

Read to Section A, June, 1948.

SETTLING OF SAND-DUNES IN MOZAMBIQUE

BY

ENG. AGR. JULIO CARDOSO.

Read to Section A, June, 1948

APPLICATION OF QUALITY CONTROL IN APTITUDE TESTS

BY

MR. H. SICHEL.

Read to Section B, June, 1948.

"NOTES ON BORING FOR WATER IN AND NEAR PRETORIA".

and

'OCCURRENCE OF BROMINE IN SOUTH AFRICAN UNDERGROUND WATER".

BY

DR. H. F. FROMMURZE.

Read to Section B, July, 1948.

Printed in "South African Science", March and April, 1949.

BIOLOGICAL AND CHEMICAL TESTS FOR EFFECTIVENESS OF BENZENE Cl_6 DIP WASHES

BY

A. B. M. WHITNALL, B. BRADFORD, W. MCHARDY, G. B. WHITEHEAD, AND F. MEERHOLZ.

Read before Section C, July, 1948 *and printed in "South African Science", December,* 1948.

PORTUGUESE MONUMENTS IN SOUTH AFRICA

BY

MR. F. R. PAVER.

Read to Section E, July, 1948 *and printed in abstract in "South African Science," January,* 1949.

THEORETICAL ASPECTS OF LEISURE-TIME ACTIVITIES OF AFRICAN MINE WORKERS

BY

MR. J. D. RHEINALLT JONES.

Read to Section F, July, 1948.

THE MOZAMBIQUE COAST

BY

DR. E. AXELSON

Read before Section F, July, 1948, *and printed in abstract in "South African Science" February,* 1949.

CITRUS GROWTH STUDIES: 1. ROOTGROWTH AND TOPGROWTH OF SEEDLINGS AND BUDLINGS; 2. FRUIT-GROWTH AND QUALITY CHANGES

BY

DR. R. H. MARLOTH.

Read before Section C, June, 1948.
Printed in full in Vol. 25 *of the British "Journal of Horticultural Science".*

SMELTING TESTS ON A LOW GRADE CASSITERITE CONCENTRATE

BY

DR. J. J. FRANKEL.

Read before Section A, June, 1948.

ADVANCES IN NUTRITION FROM WARTIME EXPERIENCE

BY

DR. A. R. P. WALKER.

Read before Section F, July, 1948

THE PEOPLE OF EARLY RHODESIA

BY

MR. W. H. STEAD.

Read before Section F, July, 1948.

RESEARCH ON ANIMAL NUTRITION AND RATIONING OF FOODSTUFFS

BY

DR. J. W. GROENEWALD.

Read before Section D, July, 1948.

THE FOOD-PRODUCING POSSIBILITIES OF THE OKOVANGO DELTA

BY

PROF J. H. WELLINGTON.

Read before Section B, July, 1948.

Printed in "South African Science," October, 1948.

POSTSCRIPT

At the Annual Congress of the Association held at Kimberley in July, 1949, a further change in the policy of the Association as regards publications has been decided upon.

The experience of the past two years has indicated that, with the present limited financial resources of the Association, the interests of its members will be best served by combining the annual Journal and monthly Bulletin into a single monthly publication, which will continue to bear the title of *South African Journal of Science*, but will be of the format of *South African Science*. Accordingly, this series of annual volumes will end with Vol. XLV, and Vol. LXVI will be the first to appear in the new form.

It will be recalled that prior to 1922, the Journal was also issued in periodical parts. In its new form, however, the Journal will not be limited to matter presented at the Annual Congress, but will also include contributed articles and news items of scientific interest such as have appeared in *South African Science* during the past two years.

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